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WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY.

E. A. BIRGE, Director

BULLETIN NO. XX ECONOMICS SERIES NO. 13

THE WATER POWERS OF WISCONSIN

BY

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PREFACE.

The remarkable development in the electrical generation and transmission of power constitutes one of the most important advances in engineering science during the past decade. This development has served to greatly emphasize the importance and value of our water power resources.

Probably not more than a half dozen other states in the Union are so favorably situated with reference to water powers as is Wisconsin. If properly husbanded and developed it seems certain that at an early date these water powers will be regarded as the most important natural resource of the state. While single developments of from 10,000 to 30,000 horse power are not wanting, it is their general distribution over nearly the entire state, rather than the great size of a few plants, that is most characteristic of Wisconsin water powers.

The total water power in the state at present developed, approximately 130,000 horse power, is only a small proportion of the total power awaiting development. While this fact may be attributed in large measure to the lack of settlement in the northern part of the state, where water powers are most abundant, it is equally true that in very many cases the failure to develop is primarily due to a lack of publicity regarding their location and value. To secure greater publicity, the legislature of 1905 appropriated $2,500 for making surveys of the water powers, and for preparing a report on the same.

The present bulletin is not to be regarded as a final report on this subject but only as a first step toward furnishing the information needed by the public. The work of collecting these data has been made doubly difficult because the lack of funds needed to prosecute the field surveys made it necessary in many cases to secure second hand information. Profiles of rivers have frequently been secured by means of railroad water levels at stream crossings. About 600 miles of river have been actually surveyed at a total cost of about

$5,000, one half of which was furnished by the U. S. Geological Survey in cooperation with the State Survey.

The Federal Survey has, however, spent approximately $18,000 since 1902, in making daily measurements of the flow of the principal Wisconsin rivers. All of these exceedingly valuable run-off records, up to December 31, 1907, are presented in this report. This work of stream measurement should be continued in the future, as the value of such run-off data greatly increases with the length of the record. It is well understood by hydraulic engineers that such records are indispensable for planning the turbine installations of new plants.

While a good beginning has already been made, much work still remains to be done in surveying the remaining water power rivers, in order that a plan and profile showing possible power developments may be prepared and printed for general distribution.

An effort has been made to give full credit for all information received. Very valuable information has been furnished the writer by prominent hydraulic engineers, especially by D. W. Mead, Messrs. Loweth & Wolf, and Messrs. O'Keef & Orbison to whom grateful acknowledgment is made.

Madison, January 1, 1908.

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WATER POWERS OF WISCONSIN.

INTRODUCTION.

Significance and extent of water-power resources.—Unlike other great natural resources of the State, such as the forest and mineral wealth, the utilization of which means the final destruction of the source of supply, the water power resources are as certain and eternal as the sunshine.[1] The importance of water powers to a State so remote from coal mines as is Wisconsin is not likely to be overestimated. Unquestionably these powers are destined to exercise a wide influence on the development of the State. So far as known, not a single important river in the State has as yet been made to fully produce its available power. The lower Fox may be said to come the nearest to this, with a total of 31,898 actual horse-power,[2] all produced in the 35 miles between Lake Winnebago and Green Bay. This large water power has caused the district to take high rank as a paper and pulp manufacturing center. Wisconsin, Chippewa, and St. Croix rivers can each be made to produce power equaling and even exceeding that of the lower Fox. Growth in the development of Wisconsin water powers has been very rapid. During the ten years ending in 1900 the gain was 75 per cent. The following figures show the growth during the last thirty-five years:

Wisconsin water powers developed.[3]

	Horsepower.
1870	33,700
1880	45,300
1890	56,700
1900	99,000
1905	124,400

[1] By this it is not meant to depreciate the decided effect of forests upon the regimen of rivers.

[2] Rept. Chief. Eng. U. S. Army, 1887, p. 2737.

[3] Census of U. S.

The annual saving represented by this power over the cost of an equivalent amount of steam power, computed at $20 per horsepower, reaches the sum of $2,500,000.

Sources of information.—Judging from the scant literature descriptive of Wisconsin water powers, but little attention has been directed in the past to this great natural resource of the State. The longest and most accurate description is contained in the Tenth Census of the United States. In Geology of Wisconsin, volume 3. 1880, will be found good detailed descriptions of the Lake Superior rivers from the standpoint of a geologist. Very reliable information regarding the upper headwaters of the larger rivers is given in the reports of the Chief of Engineers, U. S. Army, for the years 1879-1883, inclusive, to which frequent reference is herein made. This work of surveying reservoir sites involved the running of many hundred miles of levels, thus securing numerous water levels on lakes and rivers. The maps of these surveys were never published, but copies of the originals have been obtained, and no pains or expense has been spared to preserve and present these data. A fourth source of information, and a most welcome one, both because of its intrinsic value and because it marks the beginning of a rational and systematic study of Wisconsin water powers, is the detailed survey of part of Chippewa, Flambeau, Black, Wisconsin and Peshtigo rivers and the daily discharge records of the following Wisconsin water-power rivers, the latter all carried on by the United States Geological Survey for the period indicated.

No.	River.	Station.	Date Established.	Maintained at present.	Number of Measurements.	Rating curve.
1	Black	Melrose	Nov. 1902	Discontinued Aug. 1903.	7	No.
2	Black	Neillsville	April 1905	Yes	29	Yes.
3	Catfish	Madison	Dec. 1902	Dis. Aug. 1903	3	No.
4	Chippewa	Eau Claire	Nov. 1902	Yes	40	Yes.
5	Chippewa	Chippewa Falls	June 1906	Yes	13	Yes.
6	Flambeau	Ladysmith	Feb. 1903	No	22	Yes.
7	Fon du Lac	Fond du Lac	May 1903	Dis. July 1903	3	No.
8	Upper Fox	Wrightstown	Nov. 1902	Dis. Dec. 1903	11	Yes.
9	Oconto	Gillett	June 7, 1906	Yes	12	Yes.
10	Oconto	Stiles	Apr. 20, 1906	Dis. June 6, 1906.	2	No.
11	Peshtigo	Crivitz	Apr. 29, 1906	Yes	3	No.
12	Wisconsin	Grand Rapids	Miscellan's		3	No.
13	Wisconsin	Muscady	Dec. 1902	Dis. Jan. 1904.	7	Yes.
14	Wisconsin	Merrill	Dec. 1902	Yes	23	Yes.
15	Wisconsin	Necedah	Dec. 1902	Yes	23	Yes.
16	Wisconsin	Rhinelander	Nov. 1905	Yes	10	No.
17	Wolf	Northport	Apr. 1905	Dis. Dec. 1905.	6	Yes.
18	Wolf	Winneconne	Nov. 1902	Dis. July, 1903.	9	No.
19	Wolf	Shawano	June 6, 1906	Yes	2	No.
29	Menomonee	Iron Mountain	Sept. 4, 1902	Yes	28	Yes,
21	Menomonee	Koss	June 21, '07	Yes	6	No.
22	Red Cedar	Menominee	June 18, '07	Yes	7	No.

In addition to the above the United States Engineers have made daily measurements of the discharge of Fox River at Rapide Croche dam since 1896. Loweth and Wolf, civil engineers, have made measurements of the St. Croix River between 1902 and 1905 at St. Croix Falls, but the construction of the new dam at that point prevents further measurements.

EXPLANATION AND USE OF TABLES.

For each regular gaging station are given, as far as available, the following data:

List of discharge measurements.

Gage-height table.

Rating table.

Table of monthly and yearly discharges and run-off.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and use the station, and they also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, the name of the hydrographer, the width and area of cross section, the gage height, and the discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage heights taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The discharge measurements and gage heights are the base data from which the other tables are computed. In cases of extensive development, it is expected that engineers will use these original data in making their calculations, as the computations made by the Survey are based on the data available at the time they are made and should be reviewed and, if necessary, revised when additional data are available.

The rating table gives the discharge in second-feet, corresponding to various stages of the river, as given by the gage heights. It is

published to enable engineers to determine the daily discharge in case this information is desired.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise, in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this the computations for the remaining columns are based.

The values in the table of monthly discharge are intended to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates.

Recognizing the economic importance of Wisconsin water powers, the United States Geological Survey authorized, in 1903, a preliminary report on the water powers of Northern Wisconsin. This report, known as Water Supply paper, No. 156, by L. S. Smith, was not published until June, 1906. It forms a part of this report.

Recognizing further the importance of accurate information on this subject, the legislature of 1904–5 appropriated $2,500.00 for the purpose of surveying and mapping the water power rivers of the state. The United States Geological Survey promptly expressed its willingness to duplicate this amount, and a contract for a coöperative survey by joint state and federal authority was duly signed in August, 1905. Survey parties were promptly placed in the field on some of the most important water power streams, and the work of surveying and mapping the rivers was actively continued until the funds were exhausted.

By means of a well devised plan of work which, while insuring needed accuracy, avoided unnecessary refinement, as well as by a careful husbandry of the funds, the cost of this work has been about one-half that of similar coöperative work in other states. Maps and profiles have been prepared of the following rivers:

River.	Location of survey.	Miles.	Remarks.
Black River	Black River Falls to Withee.....	67	Plan and profile
Flambeau river.....	Mouth to source.	132	Plan and profile
Wisconsin river.....	Kilbourn to Tomahawk Dam.....	197	Plan and profile
Eau Claire river.....	Mouth to above "the Dalles".....	30	Plan and profile
Peshtigo river.....	Mouth to head of Taylor Rapids..... ...	82	Plan and profile
Milwaukee river.....	Mouth to Kewaskum	71	Profile only. ..

River.	Location of Survey.	Miles.	Remarks.
Rock River	[1]Beloit to Horicon....	129	Profile only.
Fox River.....	[1]Portage to Green Bay	130	" "
Beaver Dam River ...	Fox Lake to Leipsic.....	8	" "
Chippewa River.....	[2]Mouth to Flambeau, Wis.....	108	" "

[1]Surveyed by the Engineers of the United States Army.
[2]Surveyed by the United States Geological Survey.

Because the physical geography and other conditions of northern Wisconsin differ so radically from those of southern Wisconsin, it has been deemed best to discuss the water powers of these regions separately.

PHYSICAL GEOGRAPHY OF NORTHERN WISCONSIN.

GEOLOGY.[1]

The rock formations of northern Wisconsin readily fall into three classes—the pre-Cambrian crystalline rocks, the Paleozoic rocks, and the Glacial drift. The pre-Cambrian and Paleozoic formations are adjacent to one another, but the loose Glacial drift is distributed irregularly over all the hard-rock formations of the region.

PRE-CAMBRIAN ROCKS.

The pre-Cambrian crystalline rocks consist of various kinds of igneous rocks, such as greenstone or trap rocks, granite, diorite, rhyolite, schists, and gneisses, and varieties of metamorphosed sedimentary rocks, such as quartzite, slate, limestone, conglomerate ferruginous rocks, slate, and schists. The rocks here classed as pre-Cambrian include all those often referred to as the Laurentian (Archean), Huronian, and Keweenawan series. The various kinds of crystalline rocks generally stand on edge, trend in various directions, and form irregular belts and areas throughout the region.

The area of crystalline rocks covers the principal part of northern Wisconsin. Its northern boundary is approximately parallel to and very near the adjacent shore of Lake Superior; on the west it projects irregularly into Minnesota; on the south it extends to the central part of the State, and on the east it reaches within 25 to 40 miles of Green Bay.

The pre-Cambrian region is the highest portion of the State, and in these crystalline highlands the large rivers have their source and

[1] Prepared by S. Weidman, State geologist of Wisconsin.

flow outward in all directions. The crystalline rocks are generally hard. They do not everywhere have this character, however, and the lack of uniformity causes much irregularity in the surface features. High, rounded knobs of hard granite and quartzite dot the surface of the region, and the abrupt variations in the character of the rock along the river valleys have caused the formation of numerous rapids and waterfalls. The slope of the pre-Cambrian region is relatively steep on the Lake Superior side and comparatively gentle toward the east, south, and west.

PALEOZOIC ROCKS.

The Paleozoic rocks consist of alternating formations of comparatively incoherent, friable sandstone and hard, compact limestone lying unconformably upon the upturned edges of the crystalline rocks and dipping slightly toward the north, east, south, and west—the dip thus being away from the broad central core of the pre-Cambrian region. The Paleozoic rocks of northern Wisconsin include the following formations, named from the base upward: (1) Cambrian ("Potsdam") sandstone, (2) "Lower Magnesian" limestone, (3) St. Peter sandstone, and (4) "Trenton" limestone.

The Cambrian sandstone is by far the most abundant Paleozoic rock of the region. Along the shore of Lake Superior, where it is generally called the Lake Superior sandstone, it forms a strip less than a mile in width at the Michigan boundary, increasing to 15 miles in width at the Minnesota boundary. For variable distances of 15 to 40 miles about the broad central area of the pre-Cambrian to the west, south, and east, the Cambrian is the principal surface rock. It is only adjacent to the shore of Green Bay on the east and in St. Croix and Pierce counties on the west, that limestone and sandstone later than the Cambrian occur to any notable extent.

The surface features of the Cambrian sandstone district are mainly broad valley bottoms, dotted here and there with a few pinnacles of hard sand rock. In the region of the limestone, however, the valleys are generally sharp and narrow, and the uplands constitute the main portion of the landscape. The hills and sharp ravines in the limestone district are in sharp contrast with the broad, graded valley bottoms of the sandstone district.

GLACIAL DRIFT.

The Glacial drift consists of a loose, incoherent mass of bowlders, gravel, sand, and clay. In some places the coarse drift is abundant, while in other places clays and sand prevail. The drift has a very irregular thickness throughout the area. It was deposited upon the older crystalline and Paleozoic rocks during the several successive glaciations in Wisconsin and the adjacent region.

Drift in variable quantity occurs throughout northern Wisconsin, being very abundant in the northeastern, northern, and northwestern parts of the region, while in a very irregular but considerable area in the southwestern part the drift is very thin.

The surface of a large part of the drift-covered region is very irregular and uneven, and consists of hills and ridges alternating with basins, swamps, and lakes. In some places the drift covering completely obliterates the topographic features of the crystalline and Paleozoic rocks; in other places it only modifies the older topography. On the whole, however, the glaciation of the region exerted a considerable influence on the distribution of the drainage lines and in shaping the minor inequalities of the land surface. The drift region, from the topographic point of view, may be divided into two general districts—one covered by the older drift series and the other by the later drift. In the district of the older drift, the southwestern part of northern Wisconsin, there are no lakes or ponds, and swamps are very rare. Here the topography is mature and the land has good surface drainage. In the district of the later drift, however, which includes the main portion of northern Wisconsin, the glacial deposits are abundant; ridges and hills of bowldery material occur, and lakes, swamps, and sags are common. In this district, therefore, the surface drainage is often very poor and large amounts of water are held in swamps and ponds. Here, also, there are marked differences in the surface features prevailing over large parts of the district. Along its border is the terminal moraine, often called the "kettle moraine," having a width ranging from 3 or 4 to 20 miles and consisting of numerous drift hills and ridges closely associated with sags, lakes, and ponds. This terminal moraine extends across the entire continent. In crossing this portion of the State it turns north a few miles east of Grand Rapids, thence extends to Antigo, thence in a sinuous belt westward to Barron County,

and thence southwest into Minnesota. Back of this terminal moraine—that is, to the east and north—are similar belts known as "recessional moraines," separated one from another by broad areas having the general features of the hard rocks beneath. Between the moraine belts are broad tracts of sandy land, called "barrens," which cover considerable portions of the northwestern part of the State. Along Lake Superior is a broad belt of nearly flat clay land which may be mentioned, though it has no influence on the distribution of the water powers of the region.

TOPOGRAPHY.

The abundant water-power resources of Wisconsin are the result of its unique topography. A wide and comparatively flat highland crosses the northern part of the State. This divide varies in elevation from 1,900 feet in the eastern part to 1,000 feet in the western part, and extends to within 30 miles of Lake Superior. From it the rivers descend radially in all directions except eastward. Owing to the fact that Lakes Superior and Michigan bound the State on the north and east, while Mississippi River forms the southwestern and the larger part of the western boundary, all the rivers must need find a low trough into which to discharge, and that at a short distance from their source. This condition results in a rapid fall and large water powers.

About 9 per cent of the total area considered belongs to the abrupt Lake Superior watershed and the remainder to the broad southeast, south, and southwest slopes. The divides between the rivers which drain this southern slope are almost imperceptible, in some cases being entirely lost in labyrinths of lakes and swamps.

"Hills over 300 feet in height are rare. A few 'mounds,' or isolated steep hills with extremely narrow bases, rise out of the sandy plains of Jackson and Clark counties, and a few larger, more massive hills, one 1,940 feet above the sea, occur in the valleys of the larger rivers, besides the low, broad hills which form the crests of the Penokee and Copper ranges. These hilly tracts do not cover over 5 per cent of the total area, while about 45 per cent is level upland and about 50 per cent is rolling country, of which a considerable portion is steeply rolling 'kettle' or 'pot-hole' land."[1]

[1] Roth, Filibert, Forestry Conditions of Northern Wisconsin: Bul. Wis. Geol. and Nat. Hist. Survey, No. 1, 1898, pp. 2-3.

The surface features are discussed elsewhere, under the head of "Geology," and also in connection with the drainage of each river.

Hydrography.

St. Croix, Chippewa, Black, and Wisconsin rivers drain 70 per cent of the northern half of the State, an area nearly equal to that of the State of Maine. The Lake Superior rivers drain only 9.3 per cent and those flowing into Green Bay the remaining 20.7 per cent.

In general, each of the important rivers may be divided into three divisions, differing widely in physical characteristics. First, the headwaters, marked by sluggish streams with low divides, fed by numerous and extensive swamps and lakes, frequently so interlaced that it is impossible to trace out the river divides. Here many of the lakes have dam sites forming natural reservoirs for the river below. Bowlder rapids are here of frequent occurrence. Second, a stretch of maximum descent along the center reach of the river, abounding in numerous falls and long stretches of rapids. This part of the river is always in the region of the pre-Cambrian crystalline rocks, the southern border of which marks the lower limit of the rapids.[1] Third, the lower portion of the course, where for a distance of about 50 miles the river flows through sandstone and limestone, the descent being very slight. This region is, therefore, devoid of water power. In fact, the United States Government has improved the larger rivers along this reach for the purpose of navigation without the use of locks.

As compared with the upper Mississippi basin in Minnesota, the area under discussion may be said to have a steeper grade, the middle portion, containing the main water powers, having an average fall of 3 to 8 feet to the mile. Because of the storage effect of the lakes and swamps, the low-water run-off is as high as from 0.3 to 0.8 second-foot per square mile of drainage area. Probably about a third of the total rainfall finds its way into the streams.

The general use and control of these northern rivers for logging purposes in the past tended to decrease the value of the water powers by withholding the water at times when most needed. All logging on rivers is fast disappearing. Indeed, on many rivers, like the Wisconsin, it has practically given way entirely to railroad transportation. This leaves the rivers free for the permanent develop-

[1]The only important exception to this rule is on Wisconsin River at Kilbourn, where the river descends rapidly about 16 feet in the dalles of the Potsdam sandstone.

ment of their water powers. The effect on the stage of water which these dams have had in the past suggests their enlargement, extension, and systematic operation for the sole purpose of increasing the low-water flow.

The United States engineers have surveyed 32 large reservoirs in Wisconsin and have constructed five such reservoirs in Minnesota. The total capacities of the proposed Wisconsin reservoirs are as follows:[1]

Storage capacity of proposed reservoirs in Wisconsin.

River.	Area of overflowed lands.	Storage capacity.
	Cubic feet.	*Cubic feet.*
St. Croix	[2]102,092	34,334,000.000
Chippewa	Not given.	25,239,000.000
Wisconsin	25,832	19,557,000.000
		79,130,000,000

The intelligent operation of even a part of these reservoirs would have a marked effect in steadying the river discharge. This point will be separately discussed in connection with the several rivers. It may be remarked here that nature, by providing numerous swamps and upward of 1,400 lakes for this region, has accomplished unaided a decided regulation of the water supply.

The availability of these water powers varies greatly on the different rivers, or even on parts of the same river. Those on Wisconsin River, for example, are all reached by the Chicago, Milwaukee and St. Paul Railway, which parallels the river for 100 miles, and by other railroads at certain points. The powers on the lower Chippewa are likewise available; but as yet, because of the small population, the railroads have not built generally into the upper part of the region. The rapid opening up of farms now in progress will soon bring a demand for better transportation.

SOILS.[3]

The soils of northern Wisconsin may be grouped into seven readily recognized classes.

Sandy soils are found in regions known as flood plains, and owe their origin to the sorting action of flowing water as it issued from the melting ice. The two largest areas of this type are found in

[1] Rept. Chief. Eng. U. S. Army, 1880.
[2] Including 27,406 acres in Minnesota.
[3] Condensed from F. H. King's description in Northern Wisconsin Handbook.

central portion of this region includes mixed forest in which, though the pine has nearly all been cut, there still remains over 5,000 feet of hard wood and hemlock per acre, besides other timber equally valuable. The total area covered by forests of this grade amounts to 8,000 square miles, about the same as that of the State of Massachusetts.

Mr. E. T. Sweet[1] enumerates 34 different kinds of trees which he found on the Lake Superior slope alone. Additional species found on the southern slope would increase this number considerably.

The lumberman's labors were first directed to getting out the pine, both because of its high value and because of the fact that he could float it down stream to market. This industry, including the manufacture into lumber, had an invested capital in 1900 of $100,168,000 and turned out a product valued at $81,983,000.[2] This easily places it as the most important industry of the State. Only two other States exceeded this in 1900. In the same year, according to the United States Census report, Wisconsin was the leading State of the Union in lumber and timber products, their total value being $58,000,000. The amount of pine timber is limited and already its production is waning. Its place is being taken, to a large extent, by hard-wood timber, by cedar posts and poles, and by hemlock lumber and bark. The changes wrought annually by the lumberman's ax and the succeeding forest fires are very considerable. The recent appointment of a State forestry commission promises much for the protection and fostering care of these great interests.

The once popular belief that this northern area was worthless after the loss of its timber has given way in the past ten years to a general confidence in its agricultural possibilities. This is amply evidenced by the rapidity with which these lands are being opened up by farmers and by their rapid appreciation in market value. In 1895 only 7 per cent of the 18,000,000 acres of the northern half of Wisconsin was cultivated. This region has furnished 85,000,000,000 feet B. M. of pine lumber alone in the past sixty years. The gradual clearing of the timber has doubtless had an effect on the run-off of the rivers. Under the changing conditions the rainfall will be less absorbed by the soil and will get to the streams in a shorter period. This is especially true of the swamps, where the fires have burned the thick humus and moss which formerly delayed the pass-

[1] Geol. Wisconsin, vol. 3, 1880, p. 328.
[2] U S. Census, 1900, pt. 1, p. 293.

age of the water to the lakes and rivers. It is only fair, however, to call attention to the fact that large areas of the original timber consumed by forest fires have been replaced by a second growth of both hard and soft timber, much of it in the form of dense thickets, which shade and protect the ground more effectually even than the original forest.

Climatic Conditions.

TEMPERATURE.

The climate of this region is characterized by a large amount of sunshine, with high temperatures in summer and extreme cold, deep snows, and clear skies in winter. The summer heat and winter cold are generally tempered by the influence of the bordering lakes. Lakes Superior and Michigan cover an area of over 54,000 square miles and never freeze over in winter. Although the prevailing wind is from some westerly quarter, this is so frequently broken up by the passing of storm centers from the lakes that both the temperature and the humidity of the air are affected by these great bodies of water. Wisconsin rivers are generally frozen over between December 1 and March 30. The following table gives the highest and lowest temperatures for each month of the year for the twelve years ending 1883 at places in or adjacent to this region:

Highest and lowest temperatures for each month of the year for the twelve years ending 1883.[1]

Locality.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Duluth:												
Maximum	51	57	62	75	91	92	99	93	90	78	65	51
Minimum	—38	—34	—26	3	26	36	46	45	30	8	—29	—34
Marquette:												
Maximum	56	69	70	81	92	95	100	96	97	87	66	59
Minimum	—26	—27	—14	3	22	31	40.3	39.7	28	18	— 9	—20
Escanaba:												
Maximum	45	52	57	65	83	88	92	89	84	7[illegible]	61	48
Minimum	—26	—32	—20	2	20	34	42	38	26	1[illegible]	9	—23
Alpena:												
Maximum	52	58	66	72	91	97	97	92	99	83	63	56
Minimum	—27	—27	—14	2	22	33.5	45	40	29.3	22	— 4	—15
St. Paul:												
Maximum	49	59	68	82	94	94	100	98	94	87	72	56
Minimum	—31	—32	—22	7	24	39	46	43	30	15	—24	—30
La Crosse:												
Maximum	59	65	72	83	96	98	101	96	92	84	70	60
Minimum	—43	—34	23	10	29	40	52	44	31	18	—21	—37

[1] King, F. H., Northern Wisconsin Handbook, 1896.

In connection with the sudden lowering of the winter temperature, a most interesting phenomenon was observed on St. Croix River by United States engineers in the early winter of 1882.[1]

"This was the apparently close relation between the temperature and the mean velocity and discharge of the stream, the stand of the water being at the same time nearly constant. In the early winter it was found that each cold wave which increased the thickness of the ice about one-tenth of a foot at a time was accompanied by a great falling off of the discharge, to be followed by a partial recovery during the next few days, the same phenomenon recurring with great regularity at each cold wave. The recovery of discharge being in each case only partial, the gradual tendency was downward until the apparent minimum was reached, when there was no appreciable change for several weeks."

PRECIPITATION.

The average rainfall for twenty-five years over the entire State is close to 32.3 inches, distributed by seasons as follows: Winter, 4.7 inches; spring, 7.6 inches; summer, 11.7 inches; autumn, 8.3 inches. If the rainfall of the northern half alone be considered, these figures would probably need to be slightly increased. It is worthy of note that 60 per cent of the rainfall comes in the summer and autumn months, while the least fall is during the winter months. December, January, and February are the months of minimum run-off, both because of smaller precipitation and because of low temperatures and resulting deep frosts. Minimum run-off may also occur in very dry summers.

In general, it may be said that the precipitation in Wisconsin exceeds that of Minnesota and Michigan and about equals that of Iowa.

[1] Rept. Chief. Eng. U. S. Army, 1883, p. 1470.

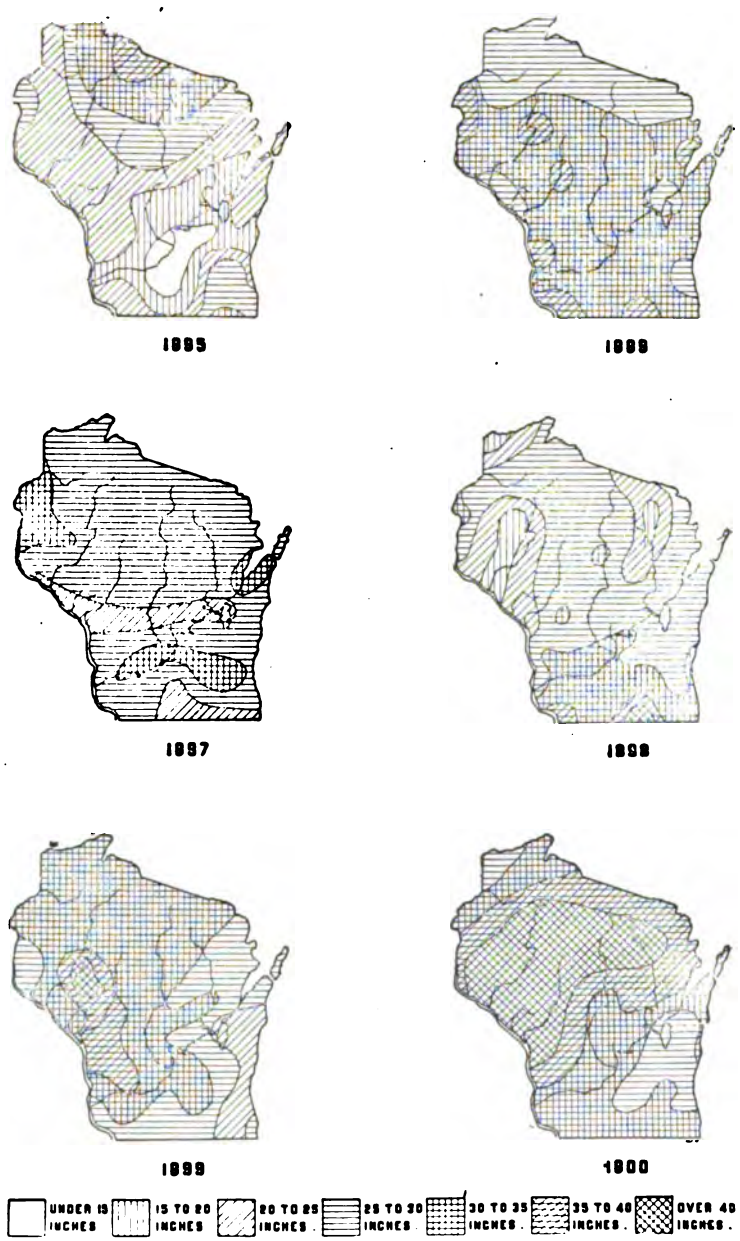

Fig. 1.—Distribution of Rainfall in Wisconsin

WATER POWERS OF WISCONSIN.

INTRODUCTION.

Significance and extent of water-power resources.—Unlike other great natural resources of the State, such as the forest and mineral wealth, the utilization of which means the final destruction of the source of supply, the water power resources are as certain and eternal as the sunshine.[1] The importance of water powers to a State so remote from coal mines as is Wisconsin is not likely to be overestimated. Unquestionably these powers are destined to exercise a wide influence on the development of the State. So far as known, not a single important river in the State has as yet been made to fully produce its available power. The lower Fox may be said to come the nearest to this, with a total of 31,898 actual horse-power,[2] all produced in the 35 miles between Lake Winnebago and Green Bay. This large water power has caused the district to take high rank as a paper and pulp manufacturing center. Wisconsin, Chippewa, and St. Croix rivers can each be made to produce power equaling and even exceeding that of the lower Fox. Growth in the development of Wisconsin water powers has been very rapid. During the ten years ending in 1900 the gain was 75 per cent. The following figures show the growth during the last thirty-five years:

Wisconsin water powers developed.[3]

	Horsepower.
1870	33,700
1880	45,300
1890	56,700
1900	99,000
1905	124,400

[1] By this it is not meant to depreciate the decided effect of forests upon the regimen of rivers.

[2] Rept. Chief. Eng. U. S. Army, 1887, p. 2737.

[3] Census of U. S.

The annual saving represented by this power over the cost of an equivalent amount of steam power, computed at $20 per horsepower, reaches the sum of $2,500,000.

Sources of information.—Judging from the scant literature descriptive of Wisconsin water powers, but little attention has been directed in the past to this great natural resource of the State. The longest and most accurate description is contained in the Tenth Census of the United States. In Geology of Wisconsin, volume 3. 1880, will be found good detailed descriptions of the Lake Superior rivers from the standpoint of a geologist. Very reliable information regarding the upper headwaters of the larger rivers is given in the reports of the Chief of Engineers, U. S. Army, for the years 1879-1883, inclusive, to which frequent reference is herein made. This work of surveying reservoir sites involved the running of many hundred miles of levels, thus securing numerous water levels on lakes and rivers. The maps of these surveys were never published, but copies of the originals have been obtained, and no pains or expense has been spared to preserve and present these data. A fourth source of information, and a most welcome one, both because of its intrinsic value and because it marks the beginning of a rational and systematic study of Wisconsin water powers, is the detailed survey of part of Chippewa, Flambeau, Black, Wisconsin and Peshtigo rivers and the daily discharge records of the following Wisconsin water-power rivers, the latter all carried on by the United States Geological Survey for the period indicated.

No.	River.	Station.	Date Established.	Maintained at present.	Number of Measurements.	Rating curve.
1	Black	Melrose	Nov. 1902	Discontinued Aug. 1903.	7	No.
2	Black	Neillsville	April 1905	Yes	29	Yes.
3	Catfish	Madison	Dec. 1902	Dis. Aug. 1903	3	No.
4	Chippewa	Eau Claire	Nov. 1902	Yes	40	Yes.
5	Chippewa	Chippewa Falls	June 1906	Yes	13	Yes.
6	Flambeau	Ladysmith	Feb. 1903	No	22	Yes.
7	Fon du Lac	Fond du Lac	May 1903	Dis. July 1903	3	No.
8	Upper Fox	Wrightstown	Nov. 1902	Dis. Dec. 1903	11	Yes.
9	Oconto	Gillett	June 7, 1906	Yes	12	Yes.
10	Oconto	Stiles	Apr. 20, 1906	Dis. June 6, 1906.	2	No.
11	Peshtigo	Crivitz	Apr. 29, 1906	Yes	3	No.
12	Wisconsin	Grand Rapids	Miscellan's		3	No.
13	Wisconsin	Muscady	Dec. 1902	Dis. Jan. 1904.	7	Yes.
14	Wisconsin	Merrill	Dec. 1902	Yes	23	Yes.
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In addition to the above the United States Engineers have made daily measurements of the discharge of Fox River at Rapide Croche dam since 1896. Loweth and Wolf, civil engineers, have made measurements of the St. Croix River between 1902 and 1905 at St. Croix Falls, but the construction of the new dam at that point prevents further measurements.

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In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise, in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this the computations for the remaining columns are based.

The values in the table of monthly discharge are intended to give only a general idea of the conditions of flow at the station, and it is not expected that they will be used for other than preliminary estimates.

Recognizing the economic importance of Wisconsin water powers, the United States Geological Survey authorized, in 1903, a preliminary report on the water powers of Northern Wisconsin. This report, known as Water Supply paper, No. 156, by L. S. Smith, was not published until June, 1906. It forms a part of this report.

Recognizing further the importance of accurate information on this subject, the legislature of 1904–5 appropriated $2,500.00 for the purpose of surveying and mapping the water power rivers of the state. The United States Geological Survey promptly expressed its willingness to duplicate this amount, and a contract for a coöperative survey by joint state and federal authority was duly signed in August, 1905. Survey parties were promptly placed in the field on some of the most important water power streams, and the work of surveying and mapping the rivers was actively continued until the funds were exhausted.

By means of a well devised plan of work which, while insuring needed accuracy, avoided unnecessary refinement, as well as by a careful husbandry of the funds, the cost of this work has been about one-half that of similar coöperative work in other states. Maps and profiles have been prepared of the following rivers:

River.	Location of survey.	Miles.	Remarks.
Black River	Black River Falls to Withee.....	67	Plan and profile
Flambeau river.....	Mouth to source.	132	Plan and profile
Wisconsin river.....	Kilbourn to Tomahawk Dam.....	197	Plan and profile
Eau Claire river.....	Mouth to above "the Dalles".....	30	Plan and profile
Peshtigo river.....	Mouth to head of Taylor Rapids..... ...	82	Plan and profile
Milwaukee river.....	Mouth to Kewaskum	71	Profile only. ..

River.	Location of Survey.	Miles.	Remarks.
Rock River	[1]Beloit to Horicon....	129	Profile only.
Fox River.....	[1]Portage to Green Bay	130	" "
Beaver Dam River ...	Fox Lake to Leipsic.....	8	" "
Chippewa River.....	[2]Mouth to Flambeau, Wis.....	108	" "

[1]Surveyed by the Engineers of the United States Army.
[2]Surveyed by the United States Geological Survey.

Because the physical geography and other conditions of northern Wisconsin differ so radically from those of southern Wisconsin, it has been deemed best to discuss the water powers of these regions separately.

PHYSICAL GEOGRAPHY OF NORTHERN WISCONSIN.

GEOLOGY.[1]

The rock formations of northern Wisconsin readily fall into three classes—the pre-Cambrian crystalline rocks, the Paleozoic rocks, and the Glacial drift. The pre-Cambrian and Paleozoic formations are adjacent to one another, but the loose Glacial drift is distributed irregularly over all the hard-rock formations of the region.

PRE-CAMBRIAN ROCKS.

The pre-Cambrian crystalline rocks consist of various kinds of igneous rocks, such as greenstone or trap rocks, granite, diorite, rhyolite, schists, and gneisses, and varieties of metamorphosed sedimentary rocks, such as quartzite, slate, limestone, conglomerate ferruginous rocks, slate, and schists. The rocks here classed as pre-Cambrian include all those often referred to as the Laurentian (Archean), Huronian, and Keweenawan series. The various kinds of crystalline rocks generally stand on edge, trend in various directions, and form irregular belts and areas throughout the region.

The area of crystalline rocks covers the principal part of northern Wisconsin. Its northern boundary is approximately parallel to and very near the adjacent shore of Lake Superior; on the west it projects irregularly into Minnesota; on the south it extends to the central part of the State, and on the east it reaches within 25 to 40 miles of Green Bay.

The pre-Cambrian region is the highest portion of the State, and in these crystalline highlands the large rivers have their source and

[1] Prepared by S. Weidman, State geologist of Wisconsin.

flow outward in all directions. The crystalline rocks are generally hard. They do not everywhere have this character, however, and the lack of uniformity causes much irregularity in the surface features. High, rounded knobs of hard granite and quartzite dot the surface of the region, and the abrupt variations in the character of the rock along the river valleys have caused the formation of numerous rapids and waterfalls. The slope of the pre-Cambrian region is relatively steep on the Lake Superior side and comparatively gentle toward the east, south, and west.

PALEOZOIC ROCKS.

The Paleozoic rocks consist of alternating formations of comparatively incoherent, friable sandstone and hard, compact limestone lying unconformably upon the upturned edges of the crystalline rocks and dipping slightly toward the north, east, south, and west—the dip thus being away from the broad central core of the pre-Cambrian region. The Paleozoic rocks of northern Wisconsin include the following formations, named from the base upward: (1) Cambrian ("Potsdam") sandstone, (2) "Lower Magnesian" limestone, (3) St. Peter sandstone, and (4) "Trenton" limestone.

The Cambrian sandstone is by far the most abundant Paleozoic rock of the region. Along the shore of Lake Superior, where it is generally called the Lake Superior sandstone, it forms a strip less than a mile in width at the Michigan boundary, increasing to 15 miles in width at the Minnesota boundary. For variable distances of 15 to 40 miles about the broad central area of the pre-Cambrian to the west, south, and east, the Cambrian is the principal surface rock. It is only adjacent to the shore of Green Bay on the east and in St. Croix and Pierce counties on the west, that limestone and sandstone later than the Cambrian occur to any notable extent.

The surface features of the Cambrian sandstone district are mainly broad valley bottoms, dotted here and there with a few pinnacles of hard sand rock. In the region of the limestone, however, the valleys are generally sharp and narrow, and the uplands constitute the main portion of the landscape. The hills and sharp ravines in the limestone district are in sharp contrast with the broad, graded valley bottoms of the sandstone district.

GLACIAL DRIFT.

The Glacial drift consists of a loose, incoherent mass of bowlders, gravel, sand, and clay. In some places the coarse drift is abundant, while in other places clays and sand prevail. The drift has a very irregular thickness throughout the area. It was deposited upon the older crystalline and Paleozoic rocks during the several successive glaciations in Wisconsin and the adjacent region.

Drift in variable quantity occurs throughout northern Wisconsin, being very abundant in the northeastern, northern, and northwestern parts of the region, while in a very irregular but considerable area in the southwestern part the drift is very thin.

The surface of a large part of the drift-covered region is very irregular and uneven, and consists of hills and ridges alternating with basins, swamps, and lakes. In some places the drift covering completely obliterates the topographic features of the crystalline and Paleozoic rocks; in other places it only modifies the older topography. On the whole, however, the glaciation of the region exerted a considerable influence on the distribution of the drainage lines and in shaping the minor inequalities of the land surface. The drift region, from the topographic point of view, may be divided into two general districts—one covered by the older drift series and the other by the later drift. In the district of the older drift, the southwestern part of northern Wisconsin, there are no lakes or ponds, and swamps are very rare. Here the topography is mature and the land has good surface drainage. In the district of the later drift, however, which includes the main portion of northern Wisconsin, the glacial deposits are abundant; ridges and hills of bowldery material occur, and lakes, swamps, and sags are common. In this district, therefore, the surface drainage is often very poor and large amounts of water are held in swamps and ponds. Here, also, there are marked differences in the surface features prevailing over large parts of the district. Along its border is the terminal moraine, often called the "kettle moraine," having a width ranging from 3 or 4 to 20 miles and consisting of numerous drift hills and ridges closely associated with sags, lakes, and ponds. This terminal moraine extends across the entire continent. In crossing this portion of the State it turns north a few miles east of Grand Rapids, thence extends to Antigo, thence in a sinuous belt westward to Barron County,

and thence southwest into Minnesota. Back of this terminal moraine—that is, to the east and north—are similar belts known as "recessional moraines," separated one from another by broad areas having the general features of the hard rocks beneath. Between the moraine belts are broad tracts of sandy land, called "barrens," which cover considerable portions of the northwestern part of the State. Along Lake Superior is a broad belt of nearly flat clay land which may be mentioned, though it has no influence on the distribution of the water powers of the region.

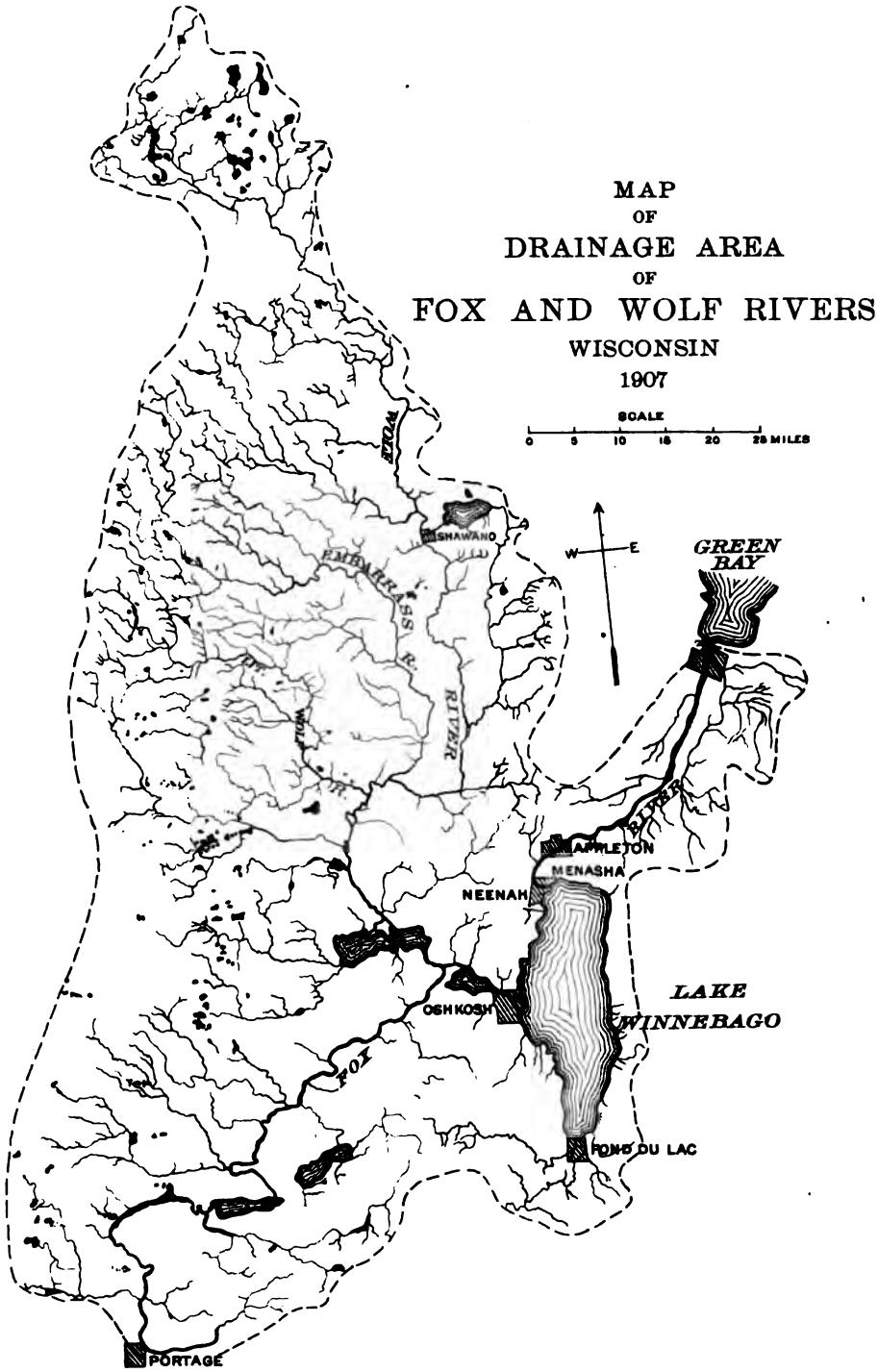
TOPOGRAPHY.

The abundant water-power resources of Wisconsin are the result of its unique topography. A wide and comparatively flat highland crosses the northern part of the State. This divide varies in elevation from 1,900 feet in the eastern part to 1,000 feet in the western part, and extends to within 30 miles of Lake Superior. From it the rivers descend radially in all directions except eastward. Owing to the fact that Lakes Superior and Michigan bound the State on the north and east, while Mississippi River forms the southwestern and the larger part of the western boundary, all the rivers must need find a low trough into which to discharge, and that at a short distance from their source. This condition results in a rapid fall and large water powers.

About 9 per cent of the total area considered belongs to the abrupt Lake Superior watershed and the remainder to the broad southeast, south, and southwest slopes. The divides between the rivers which drain this southern slope are almost imperceptible, in some cases being entirely lost in labyrinths of lakes and swamps.

"Hills over 300 feet in height are rare. A few 'mounds,' or isolated steep hills with extremely narrow bases, rise out of the sandy plains of Jackson and Clark counties, and a few larger, more massive hills, one 1,940 feet above the sea, occur in the valleys of the larger rivers, besides the low, broad hills which form the crests of the Penokee and Copper ranges. These hilly tracts do not cover over 5 per cent of the total area, while about 45 per cent is level upland and about 50 per cent is rolling country, of which a considerable portion is steeply rolling 'kettle' or 'pot-hole' land."[1]

[1] Roth, Filibert, Forestry Conditions of Northern Wisconsin: Bul. Wis. Geol. and Nat. Hist. Survey, No. 1, 1898, pp. 2-3.


MAP
OF
DRAINAGE AREA
OF
FOX AND WOLF RIVERS
WISCONSIN
1907
SCALE
0 5 10 15 20 25 MILES
W
E
GREEN BAY
SHAWANO
EMBARRASS R.
WOLF
RIVER
FOX
APPLETON
MENASHA
NEENAH
OSHKOSH
LAKE WINNEBAGO
FOND DU LAC
PORTAGE

FOX RIVER SYSTEM.

Drainage.

Lake Winnebago, the largest inland lake in Wisconsin, divides Fox River into two radically different sections, the upper and the lower Fox. The upper river approaches from the southeast to within about a mile of Wisconsin River at Portage, then turns to the northeast on its course to Lake Winnebago. It winds, with low banks, through broad savannas having only a gentle slove, passing a total distance of 25 miles through three long lakes before reaching Lake Winnebago.

"Mud Lake, Buffalo Lake, and Lake Puckaway, have been caused by the deposits of affluents which the main stream has not been able to wash away, plainly indicating that the present upper Fox did not erode its course, for it has not even the power to keep itself free, but instead is filling up. Lake Butte des Morts and Lake Winnebago are depressions which the present tendency is to fill up."[1]

Major Warren's hypotheses for these peculiar conditions have been widely accepted, and are so interesting that they are here given:

"We have only to suppose that all the waters of Lake Winnebago basin (including that of the upper Fox) formerly drained to Wisconsin River; that a slow change of level in this region elevated the southwestern part and depressed the northeastern part till a large lake was formed, which finally overflowed, forming the course of the lower Fox. This explains the present doubling back in the course of the upper Fox and tributaries, and it accounts for the close relation and yet opposite courses of Fox and Wisconsin rivers. As the level changed, the erosion at the outlet could not keep pace with it and so prevent a lake forming, because a granite ridge lies near the surface between the Wisconsin and Buffalo Lake. When the lower Fox outlet formed, the loose material covering the rocks rapidly gave way and

[1] Warren, G. K., Rept. on Wisconsin and Fox rivers, 1876.

lowered the lake level down to the rock, which now (1875) keeps it to its present level. The period of this change was post-Glacial, because this alluvial terrace is free from Glacial drift which it could not have been if formed before in a region like this, surrounded by Glacial drift deposit."

UPPER FOX.

Fox River descends only 35.3 feet in the 106.8 miles between Portage and Lake Winnebago—an average fall of less than 0.5 foot to the mile.

The following table shows the river profile in detail as given by United States engineers:

Profile of Fox River from Lake Winnebago (Oshkosh) to Portage lock (Fort Winnebago).

Station.	Distance— From Lake Winnebago.	Distance— Between points.	Elevation above sea level.	Descent between points. Total.	Descent between points. Per mile.
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
Lake Winnebago	0	.....	746.1	.....	
Eureka lock, crest	24.6	24.6	748.8	2.7	
Berlin lock, crest	32.9	8.3	750.6	1.8	
White River lock, crest	42.9	10.0	755.7	5.1	
Princeton lock, crest (Lake Puckawa)	52.3	9.4	760.2	9.4	0.42
Grand River lock, crest	73.0	20.7	763.9	3.7	
Montello lock, crest (Lake Buffallo)	76.3	3.3	768.9	5.0	
Governor Bend lock, crest	100.4	24.1	774.7	5.8	
Fort Winnebago lock, (Portage)	104.6	4.1	780.5	5.8	
Portage lock	106.8	2.2	781.4	0.9	

Fox River has been improved for navigation by the Federal Government along this entire distance by the building of 10 locks, but the slight fall gives few opportunities for water power.

The first dam on the Fox is at Pardeeville, where a head of 14 feet is available. Wisconsin River is about 10 feet above Fox River at Portage, and this fall could be utilized by a dam near the Fort Winnebago lock. A considerable quantity of water could be discharged through the canal with safety.

At Montello, 28 miles below, a turbine is installed under a head of 3 feet, developing power for a gristmill. No developed power is in use on the river below this point.

The three principal tributaries of the upper Fox have a fall of about 250 feet—much greater than that of the main river; they are all found on the north side. These branches, Montello, Mecan, and White rivers, start as clear, steady springs, running from the sand ridges of the drift covering that portion of the basin. They are each about 20 miles long, and would be unimportant except for the fact that their fall, combined with their steadiness of flow, makes them of considerable value.

Montello River joins the upper Fox at Montello. A dam at this point has a head of 11 feet, furnishing power for a flouring mill and a woolen mill. This head could be easily increased to 16 feet.

The following table shows the principal developed powers on the tributaries of the upper Fox.

Developed water powers on tributaries of upper Fox River.

Location and stream.	Owner and use.	Head.	H. P.
Hatton, Little River	C. F. Stollyman, flour and feed	10	33
Lawrence, Duck Creek	C. E. Pierce, flour and feed	11	70
Manchester, Grand River	G. Pfeiffer, flour	12	45
Marblehead, De Nevue Creek	D. I. Williams, flour and feed	30	30
Markesan Grand River	P. Wieski, flour and feed	11	30
Oxford, Neenah Creek	L. Larmer, flour and feed	9	70
Do	H. E. McNutt, flour and feed	14	190
Pine River, Pine Creek	Skinner & Johnson, flour and feed	14	60
Poysippe, Pine Creek	W. H. Paulsen, flour and feed	9	70
Princeton, ditch from Mecan river	Teske & Zierka, flour, feed and electric light	19	180
Ripon, Silver Creek	Nohr Milling Co., flour and feed	12	120
Saxeville, Pine Creek	B. W. Heald, flour and feed	10	54
Waumander, Waumander Creek	A. G. Ochsner, flour	15	27
Wautoma, Mecan River	William Henke, flour and feed	8	36
Westfield, Montello River	Cochran & Nettinger, flour and feed	10	85

LOWER FOX.

Geology and Topography.

East of Wolf River Valley is the more prominent though similar valley of Green Bay and Lake Winnebago. In pre-Glacial time it must have been much smaller in size, having been excavated to its present great size by the glacier. Lake Winnebago alone covers about 200 square miles, while the area of the connecting valley below (lower Fox River) is 400 square miles.

The western slope of both valleys is gradual, but the eastern slope is precipitous, being cut out of the soft Cincinnati shales overlain by the hard "Niagara" limestone. The bed is the hard "Galena" limestone of the "Trenton" series. The eastern side of the lower Fox

River drainage basin rises abruptly 100 to 200 feet above the water in Green Bay, and continues as a line of cliffs along the eastern shore of the present Lake Winnebago, and thence southward, though largely covered with drift in the southern part of the State. The glacial action sent down an immense ice sheet, cutting out the valley of Lake Michigan, while a branch tongue gouged out Green Bay Valley to its present size. On the peninsula between Green Bay and Lake Michigan was formed the prominent Kettle Range, a medial moraine.

The floor of Green Bay Valley has a rapid rise, Lake Winnebago being 166.7 feet above Green Bay. The portion of the old valley now occupied by the upper Fox was largely filled with drift, and it seems probable that to the action of the glacier in cutting down the intervening "Lower Magnesian" rampart and in partially filling the upper valley of Fox river is due the change in the flow of upper Fox and Wolf rivers through the newly enlarged Green Bay Valley to the lake. It is also likely that the change in flow is partly due to a depression toward the north, which occurred during or after the recession of the glacier, as suggested by Major Warren. This depression caused an advance of Lake Michigan, which rearranged the drift and deposited the red clays. By means of the latter this ancient shore of the lake can now be traced northward beyond Shawano, on Wolf River, westward up Fox River above Berlin, and southward to a few miles north of Fond du Lac. Lake Winnebago is a comparatively modern reservoir, formed in the valley by the deposition of glacial drift.

Profile.

The following table gives in detail the profile of the river to-day, after the extensive navigation improvements by the United States Government.

These improvements have changed the river into long stretches of slack water, with perhaps short rapids at the foot of a dam, except at Grand Kaukauna and Grand Chute, the site of the city of Appleton, where the rapids are passed by canals, while the river flows over its original steep bed.

Profile of Fox River from Lake Winnebago (Menasha) to Green Bay.[1]

Station.	Distance.		Elevation above sea level.	Descent between points.	
	From Menasha	Between points.		Total.	Per mile.
Menasha dam, crest	0.0	.....	746.1	.....	.....
Appleton upper lock, crest	5.1	5.1	736.5	9.6	1.9
Appleton locks, foot	6.3	1.2	699.7	36.8	30.6
Cedars lock, crest	9.6	3.3	699.7	.0	.0
Littlechute locks:					
Crest	10.6	1.0	690.0	9.7	9.7
Foot	11.6	1.0	653.8	36.2	36.2
Grand Kaukauna locks:					
Crest	13.3	1.7	653.8	.0	.0
Foot	14.2	.9	603 3	50.5	56.1
Rapide Croche lock:					
Crest	17.9	3.7	603.3	.0	.0
Foot	17.9	.25	593.9	9.4	37.6
Little Kaukauna lock:					
Crest	23.9	6.0	593.9	.0	.0
Foot	23.9	.2	587.7	6.2	31.0
Depere lock:					
Crest	29.8	5.9	587.7	.0	.0
Foot	29.8	.0	579.4	8.3	.....
Green Bay	35.2	5.4	579.4	.0	.....

Rainfall and Run-off.

The United States engineers have maintained a gaging station at Rapide Croche dam ever since March, 1896. The assistant engineer in charge, L. M. Mann, states that the crest of the dam at this point is well suited for a weir. Care is taken to read the gage five times daily, the mean reading being used to calculate the daily discharge.

According to these records the mean low-water discharge for the past eight years was 1,409 second-feet and the average discharge 3,007 second-feet; 2,660 second-feet may be regarded as the ordinary flow of the river. Because of the steadying effect of Lake Winnebago and the lakes above, formed by the expansion of upper Fox and Wolf rivers, the discharge of the river is remarkably uniform. At Appleton the ordinary variation from low to high water is scarcely more than two or three feet throughout the year.

The following table gives the maximum, the minimum, and the average flow for each month for nearly nine years, ending December, 1904, as measured at Rapide Croche dam, and also the rainfall and run-off for the same period:

[1] From United States engineer's profile of the river.

Estimated monthly discharge of lower Fox River at Rapide Croche dam.

[Drainage area, 6,200 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.	Per cent of rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.	
1895.							
January	4,972	2,262	3,931	0.634	0.731	.....	.....
February	5,201	2,545	4,320	.697	.726	.....	.....
March	5,796	2,062	3,947	.637	.734	.....	.....
April	12,706	3,076	8,510	1.37	1.53	.....	.....
May	6,386	4,233	5,610	.905	1.04	.....	.....
June	15,416	6,628	12,760	2.06	2.30	.....	.....
July	11,982	3,451	7,612	1.23	1.42	.....	.....
August	5,173	3,047	4,424	.714	.823	.....	.....
September	5,072	2,242	3,988	.643	.717	.....	.....
October	4,185	2,071	3,417	.551	.635	.....	.....
1896.							
March	1,739	697	1,284	.207	.239	1.14	21.0
April	1,765	406	940	.152	.170	4.39	3.87
May	4,246	1,563	3,140	.506	.583	5.28	11.1
June	4,605	2,173	3,726	.601	.670	2.75	24.4
July	3,863	880	2,787	.450	.519	3.09	16.8
August	2,607	123	1,470	.237	.273	3.09	8.83
September	390	9	146	.024	.027	3.23	.84
October	1,888	145	1,065	.172	.198	2.55	7.76
November	2,882	985	2,007	.324	.362	3.06	11.8
December	3,558	838	2,367	.382	.440	1.04	42.3
The year	.....	.....	.....	.....	.....	29.57	.....
1897.							
January	3,795	1,512	2,762	.445	.513	1.37	37.5
February	3,522	1,297	2,765	.446	.464	1.17	39.6
March	5,344	1,160	2,711	.437	.504	2.19	23.1
April	8,728	3,296	6,132	.989	1.10	2.00	55.0
May	5,344	2,519	4,016	.648	.747	1.74	42.9
June	4,749	2,032	3,246	.524	.585	5.06	11.6
July	4,071	1,297	3,200	.516	.595	3.51	16.9
August	3,230	116	1,881	.303	.349	2.00	17.4
September	1,588	272	833	.134	.150	2.53	5.9
October	2,608	299	1,424	.230	.265	2.15	12.3
November	2,664	861	1,862	.300	.335	1.50	22.3
December	3,770	806	2,314	.373	.430	.86	50.0
The year	8,728	116	2,762	.445	6.04	26.08	23.2
1898.							
January	3,158	1,426	2,559	.413	.476	.71	67.1
February	3,196	1,494	2,359	.380	.397	1.21	32.8
March	3,872	1,782	2,968	.479	.552	2.18	25.3
April	5,692	2,568	4,079	.658	.734	2.02	36.4
May	6,852	2,204	4,743	.765	.882	2.75	32.1
June	4,969	1,604	3,216	.519	.579	3.84	15.1
July	2,553	438	1,571	.253	.292	3.09	9.45
August	2,805	866	1,817	.293	.338	3.00	11.3
September	1,796	442	1,088	.175	.195	2.36	8.25
October	2,368	383	1,201	.194	.224	3.15	7.10
November	2,725	1,234	2,213	.357	.398	1.49	26.7
December	2,905	994	2,175	.351	.405	.35	116.0
The year	6,852	383	2,499	.403	5.47	26.15	20.9
1899.							
January	2,417	771	1,905	.307	.354	1.12	31.6
February	2,810	1,014	2,075	.335	.349	.90	38.8
March	3,435	995	2,252	.363	.418	2.31	18.2
April	5,707	1,447	3,657	.590	.658	3.00	21.9
May	8,767	3,787	6,209	1.00	1.15	3.08	37.3
June	8,751	4,018	6,298	1.02	1.14	5.40	21.2
July	5,171	1,741	3,786	.611	.704	3.29	21.4
August	3,505	791	1,836	.296	.341	2.73	12.5
September	1,437	707	988	.159	.177	2.68	6.60
October	2,079	398	1,144	.185	.213	3.02	7.05
November	2,648	613	2,119	.342	.382	.74	51.6
December	2,572	105	2,042	.329	.379	1.47	25.4
The year	8,767	105	2,859	.461	6.26	29.74	21.1

Estimated monthly discharge of lower Fox River at Rapide Croche dam—Con.

Month.	Discharge in second-feet.			Run-off.		Rainfall.	Per cent of rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.	
1900.							
January	2,684	841	2,174	.351	.405	.74	54.7
February	3,024	1,044	2,247	.362	.377	1.56	24.2
March	3,677	1,110	2,556	.412	.475	1.09	43.6
April	4,355	1,107	3,414	.551	.615	2.82	21.8
May	4,054	1,383	2,976	.480	.553	1.61	34.5
June	2,208	258	873	.141	.157	2.69	5.86
July	2,413	131	958	.154	.178	6.45	2.76
August	2,646	1,057	1,831	.295	.340	4.30	7.91
September	3,518	1,107	2,021	.326	.364	6.17	5.90
October	8,036	1,734	5,230	.844	.973	7.06	13.7
November	9,597	4,948	8,062	1.30	1.45	1.57	92.4
December	8,222	1,668	4,358	.702	.809	.69	117.0
The year	9,597	131	3,058	.493	6.70	36.76	18.2
1901.							
January	4,349	1,939	3,526	.569	.656	.90	72.9
February	4,634	1,825	3,773	.609	.634	.46	138.0
March	6,431	1,742	3,839	.619	.714	3.04	23.5
April	12,033	2,469	8,960	1.45	1.62	.79	205.0
May	6,905	3,453	4,994	.805	.928	2.72	34.1
June	5,087	1,741	3,723	.600	.669	4.62	14.5
July	4,557	2,045	3,501	.565	.651	6.41	10.2
August	3,846	1,130	2,176	.351	.405	2.38	17.2
September	1,687	675	1,221	.197	.220	3.96	5.56
October	3,873	9,910	2,551	.411	.474	2.93	16.2
November	3,873	1,640	3,256	.525	.586	1.25	46.9
December	3,672	1,464	2,768	.446	.514	.81	63.5
The year	12,033	675	3,691	.596	8.07	30.27	26.7
1902.							
January	3,136	765	2,263	.365	.421	.69	61.1
February	3,480	696	2,142	.345	.359	1.53	23.5
March	4,019	1,135	2,892	.466	.537	1.50	35.8
April	3,252	947	2,335	.377	.421	2.42	17.4
May	12,317	1,471	4,935	.796	.918	4.02	22.8
June	11,868	3,491	6,930	1.12	1.25	3.89	32.1
July	5,703	1,647	4,304	.694	.800	5.47	14.6
August	4,086	1,311	2,996	.467	.538	1.40	38.4
September	1,865	515	1,266	.204	.228	2.81	8.11
October	3,024	435	1,818	.293	.338	1.94	17.4
November	3,184	756	2,394	.386	.431	2.90	14.9
December	3,100	892	2,274	.367	.423	1.93	21.9
The year	12,317	435	3,037	.490	6.66	30.50	21.8
1903.							
January	3,756	1,206	2,760	.445	.513	.47	109.5
February	3,652	1,675	2,949	.476	.496	.90	62.0
March							
April	9,297	3,886	6,500	1.05	1.17	3.14	37.3
May	7,378	3,043	5,532	.892	1.03	5.87	17.5
June	6,791	2,656	5,061	.816	.910	2.14	42.5
July	5,571	1,856	4,124	.665	.767	5.47	14.0
August	4,449	1,438	3,446	.556	.641	6.23	10.3
September	5,519	1,829	4,321	.697	.778	5.91	13.2
October	5,826	2,590	4,686	.756	.872	2.75	31.7
November	5,077	1,733	3,693	.595	.664	1.14	58.3
December	3,702	1,319	2,885	.465	.536	.71	75.5
The year	9,297	1,206	4,143	.669	9.00	37.75	24.1

Estimated monthly discharge of lower Fox River at Rapide Croche dam—Con.

Month.	Discharge in second-feet.			Run-off.		Rainfall.	Per cent of rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.	
1904.							
January	3,869	1,185	3,074	.496	.571	.38	150.0
February	4,134	1,565	3,128	.505	.545	1.45	37.6
March	7,425	1,724	3,398	.548	.632	1.80	35.1
April	9,687	1,612	5,669	1.08	1.20	1.86	64.5
May	11,682	4,456	8,707	1.40	1.61	5.93	27.1
June	9,798	2,336	6,682	1.08	1.20	3.99	30.1
July	4,111	1,416	3,105	.501	.578	3.98	14.5
August	4,043	1,551	2,985	.481	.554	3.01	18.4
September	2,631	988	1,854	.299	.334	5.75	5.81
October	6,434	1,324	3,457	.558	.643	4.73	13.6
November	6,935	1,667	4,056	.654	.730	.30	243.5
December	4,594	1,812	3,618	.584	.673	2.13	31.6
The year	11,682	988	4,228	.682	9.270	35.31	26.2
1905.							
January	4,972	2,262	3,877	.625	.738	.81	.....
February	5,201	2,545	4,321	.696	.726	1.02	.....
March	5,796	2,098	4,009	.646	.745	1.65	.....
April	12,706	3,076	9,499	1.371	1.529	1.20	.....
May	6,597	4,233	5,614	.905	1.068	6.82	.....
June	15,416	6,628	12,210	1.969	2.197	7.77	.....
July	11,982	3,451	7,616	1.228	1.449	4.50	.....
August	5,173	3,047	4,424	.713	.841	4.43	.....
September	5,072	2,242	3,994	.644	.718	2.44	.....
October	4,185	2,072	3,418	.551	.650	2.35	.....
November	4,294	2,147	3,638	.586	.654	2.31	.....
December	4,421	1,851	3,461	.558	.658	1.56	.....
The year	15,416	1,851	5,423	.874	.975	36.86	.....
1906.							
January	4,637	1,748	3,699	.596	.703	2.68	.....
February	4,981	2,491	3,918	.632	.658	.92	.....
March	9,905	2,534	4,658	.751	.886	2.80	.....
April	15,919	9,153	13,723	2.213	2.567	1.38	.....
May	14,275	3,286	8,190	1.321	1.476	3.06	.....
June	6,039	2,836	4,242	.684	.763	6.68	.....
July	5,277	2,614	4,160	.671	.792	2.90	.....
August	3,438	1,523	2,710	.437	.515	4.53	.....
September	2,913	1,381	2,400	.390	.435	3.65	.....
October	3,096	811	2,202	.355	.419	4.07	.....
November	5,294	1,535	3,500	.564	.626	3.71	.....
December	6,593	2,953	5,112	.824	.972	1.98	.....
The year	15,919	811	4,876	.786	.873	36.36	.....
1907.							
January	7,014	2,703	5,231	.844	.996	2.40	.....
February	7,604	1,517	5,576	.960	.939	.26	.....
March	6,248	1,836	3,914	.631	.744	1.50	.....
April	12,190	5,063	10,161	1.639	1.901	3.04	.....
May	10,542	4,380	7,550	1.218	1.437	3.06	.....
June	7,693	3,309	5,724	.923	1.070	3.45	.....
July	6,980	2,605	4,695	.757	.893	5.65	.....
August	5,037	1,908	3,659	.590	.696	6.02	.....
September	3,686	1,565	2,552	.412	.478	3.72	.....
October	3,770	1,229	2,826	.456	.538	.63	.....
November	3,111	763	1,949	.314	.350	1.48	.....
December	3,677	828	2,287	.369	.435	1.41	.....
The year	12,190	766	4,677	.754	.841	32.62	.....

The maximum discharge in April, 1906, exceeded any previous discharge and is the highest known at this station.

The rainfall discharge data for the year 1905-7 was furnished through the courtesy of L. M. Mann, U. S. Asst. Eng., Oshkosh, Wisconsin. The rainfall for 1905-6-7 is the means of Portage Grand River and New London.

Mean daily discharge, in second-feet, of lower Fox River at Rapide Croche dam.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1895.												
1	3,012	4,672	4,697	4,798	4,373	6,028	11,982	4,884	4,698	2,071	.....	.....
2	2,262	4,328	4,438	3,185	5,852	7,339	10,639	4,963	5,072	2,132	.....	.....
3	3,350	4,766	4,285	3,076	5,880	6,935	10,433	4,964	3,387	3,546	.....	.....
4	3,781	5,164	4,260	5,064	5,910	7,225	10,585	4,936	3,048	3,584	.....	.....
5	4,447	3,765	2,846	5,595	5,949	8,277	10,664	5,173	3,788	3,366	.....	.....
6	4,269	2,689	2,611	5,908	6,135	15,416	10,639	3,411	4,102	3,554	.....	.....
7	4,285	4,785	3,982	5,804	4,493	14,244	9,415	3,385	4,487	3,932	.....	.....
8	3,024	4,973	3,998	7,052	4,233	14,178	9,206	4,382	4,395	3,057	.....	.....
9	2,967	5,063	4,021	8,803	5,546	15,132	7,865	4,847	4,430	2,504	.....	.....
10	4,244	5,009	4,419	9,422	6,386	14,286	7,416	4,898	3,969	3,899	.....	.....
11	4,422	5,173	4,214	11,435	6,155	14,122	8,803	4,242	3,106	3,971	.....	.....
12	4,594	4,061	2,704	12,354	6,037	14,060	9,124	4,847	4,372	4,022	.....	.....
13	4,559	2,892	2,264	12,706	6,066	14,559	9,066	3,577	4,144	3,884	.....	.....
14	4,102	4,830	2,062	12,187	4,642	14,585	8,769	3,383	4,327	3,764	.....	.....
15	3,112	5,201	3,892	12,033	4,399	14,219	8,521	4,849	4,447	2,774	.....	.....
16	2,497	4,785	3,685	11,033	6,179	14,365	7,165	4,997	4,243	2,227	.....	.....
17	3,916	4,723	3,876	11,110	6,165	14,588	6,699	4,937	2,856	3,955	.....	.....
18	4,244	4,637	4,313	11,637	6,274	13,981	8,860	5,027	2,326	4,052	.....	.....
19	4,602	3,369	2,529	12,277	5,891	14,277	7,873	4,785	4,236	4,086	.....	.....
20	4,654	2,545	2,098	11,879	6,115	14,279	6,597	3,047	4,405	3,939	.....	.....
21	4,619	4,839	4,228	10,336	4,803	14,191	6,577	3,526	4,447	3,956	.....	.....
22	3,027	4,910	4,490	10,639	4,386	13,419	5,804	4,794	4,294	2,088	.....	.....
23	2,963	4,847	5,796	9,406	5,804	13,674	4,583	4,892	4,337	2,173	.....	.....
24	4,742	4,777	5,757	9,032	6,047	13,513	3,451	5,036	2,974	3,917	.....	.....
25	4,829	4,356	5,626	9,208	5,880	12,524	5,797	5,019	2,242	4,021	.....	.....
26	4,576	3,055	4,508	7,661	5,830	11,892	6,179	4,804	4,030	4,069	.....	.....
27	4,974	2,575	3,546	5,862	5,841	14,021	5,498	3,593	4,421	4,081	.....	.....
28	4,653	4,186	4,353	6,164	4,566	12,265	5,545	3,518	4,162	4,160	.....	.....
29	3,413	.....	4,268	6,144	5,129	12,509	5,192	4,145	4,285	2,710	.....	.....
30	3,137	.....	4,395	3,302	6,597	12,251	3,562	4,086	4,127	2,263	.....	.....
31	4,576	.....	4,185	.....	6,312	.....	3,480	4,269	.....	4,185	.....	.....
Total	121,850	120,975	122,346	255,292	173,925	382,954	235,989	137,156	119,657	105,942	.....	.....
1896.												
1	.....	.....	888	1,272	2,406	2,789	3,694	912	259	145	985	2,821
2	.....	.....	697	1,027	2,088	4,246	3,728	1,048	298	608	1,048	3,135
3	.....	.....	1,386	922	1,563	4,246	3,761	1,512	179	838	1,512	3,230
4	.....	.....	1,226	760	1,639	4,141	2,032	2,314	78	608	1,537	3,558
5	.....	.....	1,395	1,048	3,493	4,282	880	2,461	36	683	1,872	3,135
6	.....	.....	1,338	780	3,166	3,967	1,320	2,578	36	1,440	1,872	1,952
7	.....	.....	1,430	761	3,312	3,897	3,592	2,607	179	880	1,792	2,372
8	.....	.....	1,113	922	2,993	3,135	3,394	2,490	328	1,070	1,563	2,821
9	.....	.....	919	859	3,230	4,461	3,863	1,250	390	880	1,098	2,789
10	.....	.....	1,271	904	2,032	4,282	3,728	1,392	122	1,093	2,201	2,913
11	.....	.....	1,479	859	1,575	4,005	3,761	1,818	192	608	2,229	2,913
12	.....	.....	1,407	406	3,361	4,389	2,201	1,818	136	779	2,638	2,729
13	.....	.....	1,407	644	3,427	4,106	1,952	1,765	48	1,093	2,729	1,647
14	.....	.....	1,271	859	3,476	3,296	3,592	1,723	48	964	2,729	1,673
15	.....	.....	981	922	3,538	2,913	3,525	2,006	205	922	1,115	2,519
16	.....	.....	837	985	3,396	4,037	3,525	985	145	1,098	1,160	2,460
17	.....	.....	1,437	1,048	2,686	3,796	3,694	1,352	192	1,138	2,460	2,607
18	.....	.....	1,248	985	2,460	3,897	3,296	2,006	134	908	2,729	2,578
19	.....	.....	1,486	644	3,591	3,897	1,872	2,032	78	722	2,668	2,578
20	.....	.....	1,306	608	3,897	3,897	1,672	2,061	195	1,362	2,729	1,563
21	.....	.....	1,411	943	3,897	2,431	2,913	2,006	17	1,647	2,882	1,613
22	.....	.....	1,024	943	3,897	2,461	2,607	1,899	145	1,440	1,639	2,519
23	.....	.....	1,024	901	4,071	3,967	2,514	2,454	134	1,563	1,440	2,460
24	.....	.....	1,739	985	2,729	4,211	2,607	838	36	1,613	2,608	2,431
25	.....	.....	1,461	1,273	2,387	3,932	2,607	327	112	543	2,789	838
26	.....	.....	1,224	556	3,932	4,141	1,563	123	123	556	2,821	1,160
27	.....	.....	1,179	780	4,246	3,897	1,563	259	27	1,440	2,669	838
28	.....	.....	1,605	1,027	4,071	2,608	2,913	375	9	1,272	1,818	1,792
29	.....	.....	1,337	1,765	4,161	2,173	2,669	406	374	1,845	1,205	2,913
30	.....	.....	1,522	1,765	4,071	3,696	2,490	453	134	1,888	1,672	2,607
31	.....	.....	1,707	.....	2,519	.....	2,578	312	.....	1,672	.....	2,329
Total	.....	.....	39,818	28,213	97,330	111,798	86,406	45,582	4,389	33,013	60,204	73,392

***Mean daily discharge, in second-feet, of lower Fox River at Rapide Croche dam*—Continued.**

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897.												
1	2,201	1,563	1,472	3,728	5,344	3,263	3,761	2,314	468	1,160	1,160	1,820
2	2,173	3,040	3,263	4,037	4,071	3,659	3,863	1,765	621	1,070	1,983	1,832
3	1,512	3,361	3,263	4,966	4,002	3,727	4,037	3,103	343	702	2,209	2,128
4	2,088	3,103	3,135	3,296	4,886	3,727	2,490	3,103	328	556	2,615	2,226
5	2,789	3,072	3,395	4,037	5,079	3,761	1,297	3,230	328	1,138	2,642	1,638
6	3,104	3,263	2,608	5,624	4,713	2,201	2,173	3,072	390	1,115	2,664	1,196
7	3,394	1,440	1,183	6,329	4,605	2,402	4,002	3,040	272	1,160	1,973	2,401
8	3,008	1,563	1,393	6,329	4,354	3,361	4,071	1,926	539	1,183	1,390	2,474
9	2,759	3,008	2,431	6,533	3,198	3,230	3,932	1,416	702	985	1,861	2,497
10	2,607	3,361	2,490	6,533	2,759	3,329	3,932	2,760	556	741	1,964	2,748
11	2,286	3,040	2,461	5,231	4,354	3,459	2,402	2,608	664	556	1,912	2,568
12	3,072	3,198	2,578	4,789	4,497	3,659	2,402	2,490	390	1,345	1,964	1,905
13	3,198	3,108	2,461	6,614	4,461	2,229	3,459	2,490	390	1,512	2,183	1,102
14	3,072	2,189	1,512	6,410	4,141	2,229	3,558	2,608	819	1,512	1,481	2,512
15	3,040	1,297	1,160	6,533	4,425	3,394	3,694	1,440	1,416	1,897	1,092	3,409
16	2,788	3,103	2,490	6,329	3,326	4,749	3,897	1,345	1,588	1,952	1,833	3,439
17	1,644	3,072	2,314	6,779	2,913	4,037	3,694	3,431	1,440	1,048	1,912	3,770
18	1,872	3,230	2,619	7,072	4,106	3,727	2,229	2,638	1,205	722	1,964	1,880
19	3,230	3,198	3,460	5,419	4,282	3,727	2,066	2,431	761	1,897	2,432	2,213
20	3,795	3,361	5,344	7,114	4,425	2,286	3,394	1,765	702	2,061	2,412	1,559
21	3,459	1,639	2,821	7,582	4,318	2,314	3,558	1,093	943	1,897	1,387	2,424
22	3,198	1,723	2,461	7,326	4,461	3,525	3,761	1,048	1,205	1,897	861	2,665
23	3,394	3,135	3,694	8,728	3,072	3,525	3,694	1,352	1,393	299	2,045	2,642
24	2,759	3,522	3,626	8,549	2,759	3,592	3,525	1,273	1,309	1,115	1,207	2,732
25	1,809	3,378	3,328	6,946	4,141	3,263	1,926	1,273	1,160	1,239	2,476	1,878
26	2,945	3,458	3,394	6,329	4,246	3,528	2,117	901	644	2,117	2,107	806
27	2,945	3,135	3,135	7,539	4,246	2,343	3,008	1,160	838	2,490	2,148	1,657
28	3,103	1,765	1,512	6,329	4,071	2,032	3,198	343	1,138	2,373	1,281	2,900
29	3,361	.....	1,962	5,459	4,071	3,932	3,394	374	1,183	2,608	1,097	2,808
30	3,103	.....	3,394	5,459	2,638	3,727	3,394	116	1,183	2,280	1,602	2,928
31	1,818	.....	3,094	.....	2,519	.....	3,329	403	.....	1,512	.....	2,969
Total	85,616	77,415	84,053	183,948	124,486	97,397	99,197	58,311	24,978	44,145	55,857	71,721
1898.												
1	3,063	2,793	2,676	4,056	3,776	4,969	2,553	876	1,652	602	2,609	2,805
2	2,699	2,762	2,698	4,176	3,799	4,522	2,496	1,546	1,795	554	2,351	2,766
3	1,425	2,931	2,753	2,846	5,508	4,579	1,771	1,649	1,639	517	2,237	2,714
4	2,535	3,196	2,908	2,588	5,016	4,397	438	1,670	1,317	857	2,134	1,789
5	3,000	3,062	2,752	3,890	6,668	3,578	1,868	1,585	726	595	2,187	1,647
6	3,037	2,038	1,699	4,072	6,852	2,388	1,865	1,067	1,454	771	1,457	2,479
7	2,946	1,766	1,782	4,159	6,098	4,018	1,799	973	1,532	801	1,234	2,609
8	2,977	2,504	3,064	4,115	4,921	4,408	1,639	1,074	1,629	1,024	2,617	2,699
9	1,873	2,665	3,660	4,150	4,333	4,276	1,490	1,653	1,735	383	2,475	2,572
10	1,396	2,583	3,761	2,925	5,889	4,175	1,096	1,685	1,714	638	2,485	1,379
11	2,953	2,701	3,394	2,837	5,904	4,364	1,042	1,695	1,133	1,056	2,497	2,153
12	2,969	2,679	3,192	4,291	5,683	3,215	1,595	1,660	750	1,092	2,542	1,539
13	2,901	1,723	1,868	4,273	5,487	2,524	1,757	1,835	1,288	1,246	1,543	2,345
14	2,946	1,578	1,902	4,054	5,432	3,690	1,798	1,213	1,115	1,155	1,451	2,637
15	3,079	2,331	2,224	4,189	4,018	3,703	1,842	1,226	1,186	1,156	2,438	2,791
16	1,864	2,549	3,288	4,301	3,457	3,728	1,792	1,765	1,098	745	2,453	2,715
17	1,569	2,490	3,111	2,924	4,551	3,167	1,074	2,273	1,177	755	2,552	2,215
18	2,908	2,468	3,135	3,025	5,088	3,690	1,245	2,460	778	1,300	2,563	1,343
19	2,799	2,497	3,435	4,372	4,758	2,343	1,699	2,805	442	1,178	2,482	1,462
20	3,078	1,528	1,938	4,650	4,647	2,076	1,639	2,752	760	1,304	1,747	2,453
21	2,859	1,587	2,235	4,776	4,739	2,453	1,616	2,024	818	1,892	1,281	2,409
22	2,915	2,403	3,280	5,692	3,577	2,623	1,664	866	959	1,865	2,704	2,398
23	1,925	2,409	3,200	4,894	3,157	2,603	1,685	2,571	906	1,136	2,549	2,241
24	1,741	2,505	3,122	3,176	4,338	2,624	1,088	2,579	933	769	2,499	2,308
25	2,962	2,403	3,643	3,462	4,594	2,488	989	2,482	676	2,043	2,725	994
26	2,985	2,505	3,361	4,656	4,471	1,623	1,557	2,468	491	1,815	2,572	1,017
27	3,077	1,494	2,566	5,089	4,739	1,604	1,641	2,572	681	1,845	1,486	1,544
28	3,158	1,914	3,035	5,136	4,612	1,863	1,618	1,942	696	2,064	1,402	2,412
29	2,964	.....	3,872	4,767	3,857	2,230	1,687	1,195	877	2,233	2,606	2,446
30	1,851	.....	3,728	4,839	2,204	2,567	1,661	1,848	693	1,489	2,519	2,315
31	1,461	.....	3,739	.....	4,872	.....	1,117	1,717	.....	2,368	.....	2,244
Total	79,317	66,064	92,026	122,360	147,045	96,483	48,707	56,326	32,629	37,239	66,397	67,435

***Mean daily discharge, in second-feet, of lower Fox River at Rapide Croche dam*—Continued.**

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
1	1,533	2,111	1,931	3,279	3,787	5,209	5,042	3,345	1,292	831	2,104	2,205
2	1,488	2,174	2,113	1,837	5,020	5,238	4,031	3,505	1,437	764	2,648	2,455
3	2,366	2,275	2,134	1,447	5,121	5,432	3,133	3,121	842	1,560	2,542	1,667
4	2,417	2,261	2,113	3,756	5,417	4,733	3,678	2,396	1,003	1,037	2,446	952
5	2,187	1,453	1,352	4,249	5,395	4,018	3,361	2,418	1,411	996	1,742	2,549
6	2,393	2,458	1,279	4,641	5,500	5,518	4,923	1,745	1,121	1,193	1,261	2,411
7	2,173	2,175	1,976	4,839	4,446	5,633	5,171	956	991	1,100	2,579	2,475
8	1,466	1,303	1,932	4,425	4,145	5,565	4,726	2,043	953	928	2,622	2,572
9	1,465	2,681	2,027	2,823	5,924	5,062	3,942	2,585	996	774	2,523	2,530
10	2,316	2,572	2,062	2,249	6,192	5,369	3,019	2,394	792	964	2,635	1,775
11	2,329	2,810	2,034	3,741	6,618	4,406	4,592	2,343	578	922	2,619	1,020
12	2,316	2,047	2,355	3,821	7,601	4,334	4,715	2,357	945	1,056	1,890	2,366
13	2,106	1,711	1,336	3,812	8,050	5,878	4,882	1,547	825	1,144	1,143	2,498
14	2,406	2,588	1,913	3,976	7,301	7,091	4,852	1,250	891	982	2,187	2,352
15	1,514	2,646	2,289	3,721	7,763	7,080	4,974	1,852	889	779	2,381	2,395
16	1,604	2,534	2,692	2,199	8,562	7,681	3,773	1,812	831	898	2,351	2,339
17	2,254	2,619	2,612	2,004	8,767	7,408	3,021	1,829	831	969	2,352	1,780
18	2,379	2,453	2,553	3,461	7,838	6,702	4,516	1,946	1,001	1,039	2,261	1,259
19	2,352	1,243	1,553	3,946	8,421	6,853	4,511	1,973	1,166	1,179	1,774	2,576
20	2,347	1,291	996	3,778	8,431	8,123	4,186	1,026	996	1,304	613	2,381
21	2,330	1,902	2,731	3,955	7,046	8,096	3,881	1,163	1,039	1,327	2,301	2,388
22	1,409	2,117	3,001	4,154	6,272	8,571	3,701	1,578	991	885	2,205	2,417
23	1,506	2,152	2,756	2,798	5,263	8,515	2,459	1,609	855	685	2,237	2,497
24	1,729	1,995	2,832	2,813	5,333	8,277	1,741	1,772	707	1,480	2,209	1,752
25	1,562	2,104	2,829	4,336	5,451	7,338	3,193	1,317	719	1,551	2,352	105
26	1,690	1,395	1,910	4,524	5,263	6,594	3,336	1,339	922	1,404	1,873	958
27	1,981	1,014	1,243	4,565	5,525	7,372	3,364	944	1,138	1,829	905	2,123
28	771	2,007	3,192	5,707	5,898	6,029	3,395	791	1,099	2,029	2,329	2,185
29	1,508	.....	3,297	4,915	5,160	5,797	3,233	1,307	1,206	1,493	2,159	2,417
30	1,346	.....	3,325	3,947	5,466	5,007	2,051	1,351	1,166	769	2,330	2,241
31	1,803	.....	3,435	.....	5,513	.....	1,982	1,299	.....	2,079	.....	1,659
Total	59,044	58,091	69,802	109,716	192,489	188,928	117,383	56,913	29,633	35,450	63,573	63,299
1900.												
1	841	2,395	2,432	2,454	3,636	1,482	276	2,646	1,976	1,734	6,535	6,608
2	2,352	2,366	2,468	1,107	3,882	1,574	511	2,106	1,640	4,007	9,397	4,372
3	2,391	2,446	2,490	3,554	4,028	1,375	319	1,946	1,421	5,185	9,597	3,512
4	2,406	1,641	1,707	3,846	4,010	1,102	131	1,966	1,962	5,479	8,225	5,674
5	2,479	1,044	1,110	3,967	4,054	1,929	820	1,638	2,141	4,846	7,650	5,943
6	2,568	2,366	1,342	4,063	2,779	2,208	352	1,287	1,894	4,758	8,989	5,807
7	1,576	2,381	2,576	3,791	1,674	2,085	345	1,956	2,050	3,657	9,039	5,683
8	1,213	3,024	2,639	2,903	2,461	1,467	294	1,912	2,113	2,848	8,418	5,439
9	2,406	2,420	2,614	1,751	2,283	1,302	365	2,075	1,333	4,827	8,658	8,222
10	2,669	2,398	2,636	3,510	2,275	989	473	1,973	1,143	5,165	9,260	3,586
11	2,684	1,675	1,921	3,770	2,240	1,013	353	2,043	1,973	5,117	7,830	5,245
12	2,646	1,071	1,352	4,067	2,285	1,217	333	1,498	2,071	4,813	7,567	5,652
13	2,677	2,316	2,666	4,006	1,784	1,189	394	1,037	2,187	4,668	8,775	5,075
14	1,736	2,654	2,973	4,080	1,753	756	382	1,825	2,075	3,559	8,456	5,301
15	1,236	2,707	3,036	2,560	3,741	353	538	1,905	2,184	3,028	8,076	4,099
16	2,527	2,729	2,961	2,237	3,989	497	979	1,889	1,163	4,461	6,611	2,725
17	2,424	2,662	2,935	3,942	3,799	394	1,176	2,039	1,167	4,885	6,909	2,240
18	2,639	1,895	2,069	4,355	3,885	437	1,067	2,002	1,949	5,285	5,654	4,118
19	2,534	1,314	1,354	4,089	3,791	573	907	1,434	1,899	5,254	4,948	4,292
20	2,657	2,861	2,710	4,137	2,665	523	1,192	1,120	2,062	5,703	7,536	4,314
21	1,719	2,840	2,832	4,072	2,105	569	1,152	2,120	2,020	4,599	7,875	4,378
22	1,043	2,606	2,904	2,932	3,729	585	799	2,007	2,169	4,225	8,249	4,457
23	2,632	2,687	2,954	1,977	3,937	264	1,170	1,875	1,433	6,510	8,189	4,035
24	2,549	2,646	3,298	3,856	3,872	262	1,846	1,966	1,107	6,270	8,792	1,668
25	2,461	1,434	2,259	4,089	3,889	396	2,047	1,924	2,329	7,427	7,100	3,224
26	2,579	1,296	1,300	4,106	3,694	258	1,982	1,440	2,801	7,572	6,917	2,621
27	2,420	2,411	3,159	4,063	2,539	360	1,979	1,115	2,810	7,624	8,415	4,068
28	1,508	2,624	3,644	4,225	1,383	298	1,905	1,912	3,391	6,393	8,632	4,147
29	1,219	.....	3,677	2,862	2,103	386	1,536	1,928	3,518	6,396	8,328	4,111
30	2,166	.....	3,560	2,064	2,149	341	1,672	2,127	2,561	7,855	8,239	3,191
31	2,439	.....	3,652	.....	1,859	.....	2,413	2,023	.....	8,036	.....	1,728
Total	67,396	62,909	79,228	102,435	92,273	26,184	29,708	56,754	60,632	162,120	241,866	134,935

***Mean daily discharge, in second-feet, of lower Fox River at Rapide Croche dam*—Continued.**

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	3,822	3,475	4,362	2,469	6,328	4,803	2,045	3,834	1,197	1,161	3,664	2,586
2	4,000	3,734	4,263	4,664	6,905	3,802	3,496	3,846	1,161	1,783	3,804	1,685
3	4,215	2,659	2,741	5,086	5,990	3,473	3,740	3,787	1,636	1,863	2,674	2,653
4	4,202	1,825	2,109	5,209	6,032	4,913	2,618	2,648	1,682	1,748	1,789	3,520
5	4,253	3,723	4,073	5,385	4,769	5,087	3,194	1,713	1,687	1,713	3,699	3,497
6	3,016	4,006	4,481	6,081	3,799	4,905	4,097	2,553	1,682	1,228	3,728	3,459
7	2,043	4,352	4,262	6,777	5,707	4,647	2,945	2,605	1,649	991	3,711	3,648
8	3,939	4,515	4,262	7,075	5,536	4,846	2,722	2,321	1,105	2,067	3,728	2,329
9	4,279	4,541	4,210	10,675	5,498	2,834	4,185	2,406	893	2,145	3,584	1,598
10	4,349	2,796	2,908	10,986	5,574	2,654	4,557	2,336	1,449	2,265	2,585	3,257
11	4,159	2,045	1,798	11,579	5,428	3,873	4,080	1,503	984	2,468	1,654	3,585
12	4,009	4,164	2,206	12,038	4,183	3,916	4,154	1,607	1,199	2,314	3,447	3,669
13	3,046	4,181	4,000	11,573	3,754	4,443	4,041	2,579	1,051	1,740	3,766	3,672
14	2,235	4,434	4,121	11,088	5,012	4,273	3,131	2,512	1,194	1,260	3,766	3,139
15	3,914	4,262	4,059	10,728	5,564	3,911	2,809	2,497	706	3,633	3,771	2,524
16	3,929	4,292	4,169	11,869	5,428	2,586	3,996	2,642	1,146	3,357	3,856	1,555
17	2,480	3,068	2,818	11,935	5,371	1,741	4,089	2,575	1,009	3,252	2,697	2,894
18	3,542	2,227	1,742	11,614	5,011	3,475	4,002	1,617	1,039	3,366	1,661	3,349
19	3,981	4,309	3,967	11,467	4,099	4,087	3,898	1,404	1,004	3,130	3,644	3,316
20	2,965	4,470	4,030	11,334	3,715	4,148	4,067	1,737	1,090	2,099	3,873	2,939
21	2,835	4,392	4,554	9,936	5,006	3,948	2,912	1,607	1,056	1,574	3,728	3,312
22	3,521	4,500	4,143	9,302	5,261	3,956	2,230	1,764	655	3,539	3,833	2,645
23	3,885	4,393	4,109	11,103	5,312	3,137	3,623	1,885	1,020	3,728	3,717	1,567
24	3,885	3,085	3,433	9,826	4,686	2,493	3,899	1,795	1,276	3,622	2,485	2,953
25	3,898	2,489	4,615	9,467	4,938	3,336	3,936	1,542	1,449	3,634	1,640	2,095
26	3,813	4,402	6,431	9,240	3,884	3,506	3,833	1,130	1,513	3,749	3,212	1,971
27	2,563	4,634	4,994	8,395	3,759	3,474	3,791	1,849	1,449	2,719	3,585	2,800
28	1,939	4,577	4,084	7,401	4,875	3,554	2,668	1,892	1,437	1,646	3,476	3,088
29	3,286	.....	4,367	7,244	3,453	3,506	2,138	1,932	1,073	3,597	3,432	2,177
30	3,668	.....	4,245	7,271	5,010	2,354	3,724	1,622	1,124	3,873	3,456	1,464
31	3,643	.....	3,469	.....	4,920	.....	3,921	1,725	.....	3,791	.....	2,796
Total	109,314	105,640	119,011	268,802	154,807	111,687	108,541	67,465	36,365	79,090	97,665	85,802
1902.												
1	3,096	2,595	3,368	2,765	2,393	9,573	5,703	3,727	910	1,286	2,962	987
2	3,104	917	1,190	2,964	2,469	10,488	5,601	3,276	1,111	1,499	1,004	2,930
3	2,938	1,488	1,632	3,011	2,423	11,868	5,447	1,544	1,682	1,596	1,314	2,899
4	3,060	2,446	2,497	3,106	1,471	11,462	3,372	2,532	1,600	1,498	2,716	3,060
5	1,058	2,513	2,632	3,252	2,079	11,050	3,453	3,692	1,723	435	2,931	2,907
6	1,676	2,609	2,758	1,603	2,845	10,407	3,010	3,912	1,865	736	2,854	3,022
7	2,776	2,609	2,827	1,706	3,537	9,886	3,349	4,086	704	1,576	2,973	892
8	2,860	2,408	2,754	3,134	4,079	7,311	5,534	3,999	1,224	1,751	3,012	1,662
9	3,136	696	1,135	3,102	3,131	7,886	5,533	3,894	1,709	1,613	914	2,799
10	2,993	1,427	1,575	3,147	4,018	8,343	5,326	1,532	1,759	1,613	1,273	2,845
11	2,915	2,389	3,866	3,102	2,075	8,209	5,280	2,392	1,653	1,526	2,977	3,100
12	765	2,595	3,274	3,119	2,743	6,222	5,136	3,696	1,550	651	3,028	3,045
13	1,285	2,587	3,608	1,459	4,637	6,431	4,639	4,047	1,669	1,042	2,946	2,996
14	2,494	2,477	3,690	1,759	4,917	3,998	3,264	4,031	821	2,116	2,891	1,158
15	2,344	2,455	3,567	2,108	5,056	5,840	5,125	3,853	1,083	2,931	2,891	1,335
16	2,461	1,063	1,603	2,366	4,917	4,169	5,142	3,958	965	2,250	756	2,654
17	2,514	1,421	1,765	2,449	4,615	6,156	5,265	1,500	1,203	2,219	1,308	2,665
18	2,505	2,492	3,707	2,265	2,484	6,282	5,281	2,097	1,208	2,716	2,841	2,619
19	1,139	2,413	3,841	2,376	2,692	5,439	5,163	2,539	1,317	715	2,832	2,609
20	1,099	2,587	3,841	1,089	4,682	5,992	2,896	2,733	1,174	1,455	2,962	2,088
21	2,422	2,366	3,994	2,069	5,085	6,088	3,150	2,913	652	2,120	2,954	1,256
22	2,113	2,486	3,969	2,267	4,862	3,852	4,248	2,927	887	2,646	2,915	1,609
23	2,450	1,085	1,852	2,069	4,725	4,215	4,200	2,869	1,473	2,534	958	2,602
24	2,422	1,377	1,723	2,314	4,949	5,866	4,326	1,311	1,452	2,676	1,349	2,642
25	2,429	2,210	3,777	1,986	5,719	6,089	4,566	1,773	1,174	2,681	2,977	1,404
26	927	2,424	3,925	2,247	7,422	6,001	4,287	2,763	1,369	1,086	3,184	1,579
27	1,389	2,366	4,019	947	9,941	5,707	1,647	2,891	1,336	1,286	2,860	2,654
28	2,425	3,480	3,841	1,571	11,227	5,740	2,265	2,879	515	1,787	2,962	1,142
29	2,558	.....	3,926	2,381	12,317	3,491	3,441	2,780	851	2,963	3,123	1,574
30	2,425	.....	1,769	2,312	9,869	3,852	3,733	2,158	1,222	3,024	1,138	2,468
31	2,373	.....	1,735	.....	9,599	.....	4,024	1,520	.....	2,875	.....	2,587
Total	70,151	59,981	89,660	70,042	152,978	207,913	133,414	89,732	37,971	56,360	71,805	70,479

***Mean daily discharge, in second-feet, of lower Fox River at Rapide Croche dam*—Continued.**

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1903												
1	2,587	1,675	1,829	6,192	6,009	5,677	5,571	4,393	4,195	5,312	2,664	2,819
2	2,631	2,102	1,780	6,597	6,306	6,791	5,419	2,827	4,281	5,293	2,102	3,385
3	2,587	3,008	3,191	6,806	6,145	6,069	5,278	3,011	4,298	2,805	4,674	1,915
4	1,206	3,053	3,197	7,649	4,275	5,429	3,509	3,845	4,325	2,618	4,772	3,669
5	1,479	3,097	3,453	9,297	6,118	5,386	2,055	4,136	4,324	5,321	4,769	3,628
6	2,662	3,394	3,318	7,729	5,989	5,989	2,721	3,756	1,829	4,993	4,965	1,653
7	2,818	3,387	3,665	7,661	6,237	3,747	3,943	3,707	1,936	5,826	4,929	1,273
8	2,767	1,827	2,307	6,377	6,078	4,089	3,746	3,787	3,995	5,595	1,975	3,507
9	2,837	1,837	2,070	6,349	5,911	5,812	4,093	2,206	4,708	5,339	2,098	3,621
10	2,409	3,390	3,560	6,783	3,629	5,969	3,796	2,875	4,809	5,339	4,230	3,702
11	1,559	3,581	3,981	8,283	3,964	5,564	4,009	3,671	5,007	2,845	4,950	3,595
12	1,522	3,593	4,199	7,807	5,698	6,009	1,856	4,021	5,086	2,577	5,977	3,644
13	2,954	3,652	4,064	7,402	5,467	5,735	3,370	4,134	2,734	5,340	4,731	1,623
14	3,187	3,501	3,963	8,394	5,771	3,501	4,992	4,030	2,731	5,509	4,846	1,827
15	3,610	2,008	2,550	8,517	5,467	3,818	4,684	4,134	5,199	5,482	2,226	2,964
16	3,655	2,042	2,207	6,236	5,841	5,631	5,157	1,438	5,312	5,510	1,859	3,516
17	3,493	3,368	4,178	6,216	3,421	5,668	5,149	2,003	5,293	5,434	4,219	3,694
18	1,295	3,269	4,650	6,339	3,869	5,716	5,139	4,064	5,387	2,760	4,466	3,702
19	1,953	3,285	8,437	4,188	6,088	5,354	2,700	4,099	4,442	2,957	4,888	3,677
20	3,503	3,431	6,454	4,518	6,127	5,232	3,174	4,047	3,751	5,599	4,504	2,000
21	3,746	3,468	3,887	6,429	6,127	3,326	5,047	4,021	2,489	5,134	4,282	1,916
22	3,664	2,379	1,815	6,296	5,963	3,645	4,945	1,874	5,106	5,368	1,733	3,328
23	3,436	1,749	2,340	6,657	6,157	5,429	5,102	3,869	5,369	5,293	2,307	3,424
24	3,543	3,232	5,086	5,784	3,043	5,476	5,176	1,965	5,481	5,283	4,422	1,908
25	1,293	3,107	5,055	4,796	3,824	5,411	4,918	3,794	5,415	2,590	4,484	3,353
26	1,935	3,068	4,838	3,886	6,216	5,335	2,538	4,291	5,519	2,666	3,874	1,584
27	3,289	3,457	4,839	4,376	7,378	5,204	2,180	4,449	3,481	5,133	3,310	1,319
28	3,435	3,627	4,967	6,207	6,421	2,656	4,442	4,244	2,991	5,302	3,378	2,162
29	3,527	.....	3,979	6,011	6,138	3,089	4,555	4,099	5,013	5,264	1,977	3,134
30	3,514	.....	3,337	5,288	6,657	5,084	4,254	1,781	5,059	5,217	1,873	3,619
31	3,756	.....	5,454	.....	5,199	.....	4,321	2,257	.....	5,264	.....	3,587
Total	85,57	82,58	118,643	195,015	171,503	151,841	127,848	106,828	129,635	145,268	110,591	89,448
1904.												
1	3,497	2,371	3,408	4,127	6,742	9,539	3,428	2,745	2,631	2,124	4,245	3,809
2	3,595	3,586	3,457	3,878	7,316	9,411	3,282	2,489	2,399	1,356	4,767	4,405
3	1,898	3,545	3,545	1,612	5,794	9,283	2,682	3,617	2,231	1,324	4,785	4,354
4	2,221	3,538	3,522	4,091	5,477	9,793	2,243	3,636	1,327	2,499	4,750	3,005
5	3,139	3,306	3,505	4,317	5,804	8,253	2,799	3,546	1,622	3,385	4,829	2,527
6	3,507	3,505	1,724	4,507	5,784	8,404	3,578	3,676	1,949	3,480	4,423	4,077
7	3,809	1,664	1,769	4,410	5,813	8,799	1,416	2,575	2,000	3,678	2,611	4,379
8	3,861	2,073	3,392	4,879	4,456	8,248	3,578	2,833	2,013	3,628	4,346	4,413
9	3,752	3,530	3,147	5,334	5,417	6,968	3,483	3,833	1,863	2,412	4,742	4,269
10	1,762	3,595	3,545	2,564	7,548	8,179	2,603	3,754	2,096	3,503	4,794	4,277
11	2,027	3,636	3,668	3,887	10,052	8,483	2,769	3,987	1,312	3,797	4,847	2,881
12	3,719	3,710	3,465	5,737	10,960	8,139	3,459	3,924	1,545	3,354	5,137	2,452
13	3,628	3,663	1,818	6,108	11,682	8,027	3,452	4,043	1,907	3,592	3,280	3,069
14	3,465	1,565	1,988	7,168	11,185	8,527	3,658	2,698	2,103	3,609	2,663	3,638
15	3,572	1,904	3,289	7,495	9,810	8,125	3,475	3,087	2,162	3,717	4,525	3,699
16	3,587	3,504	3,644	8,015	10,168	8,315	3,428	3,226	2,124	2,345	4,637	3,757
17	1,481	3,400	3,424	7,647	11,022	8,281	2,466	3,098	2,091	1,894	4,576	3,721
18	2,018	3,602	3,481	8,233	10,960	7,356	2,832	3,217	1,568	3,453	4,481	2,871
19	3,166	3,628	3,130	9,637	10,604	5,999	3,459	3,197	1,361	3,379	4,499	2,209
20	3,352	3,710	1,739	9,434	10,168	5,776	3,344	3,240	1,762	4,488	2,538	3,711
21	3,329	1,689	2,036	9,399	9,574	6,167	3,206	2,214	1,825	4,470	2,286	4,439
22	3,408	2,237	3,913	9,190	8,571	5,241	3,420	1,722	988	4,248	4,102	4,354
23	3,392	3,760	4,335	9,018	9,099	3,758	3,359	2,443	1,988	3,018	4,421	4,111
24	1,185	3,962	5,185	7,436	9,845	3,617	2,345	2,531	1,888	2,917	3,264	4,077
25	2,096	4,082	7,425	7,126	10,168	2,333	2,585	2,396	1,276	4,336	3,379	2,253
26	3,668	4,134	5,429	8,823	10,812	2,336	2,909	1,551	1,381	4,694	4,285	1,812
27	3,727	3,810	2,354	9,075	9,339	2,585	2,146	2,503	1,975	4,542	2,748	3,163
28	3,809	1,843	2,504	9,028	9,527	3,474	3,498	2,595	1,925	4,575	1,667	3,700
29	3,752	2,091	3,359	9,017	8,720	3,538	3,584	2,115	2,267	6,431	3,127	3,677
30	3,848	.....	3,748	8,868	8,471	3,491	4,111	2,389	2,052	3,000	6,935	4,594
31	1,885	.....	4,385	.....	8,989	.....	2,659	2,645	.....	3,158	.....	4,311
Total.	95,307	90,703	105,333	20,060	269,926	200,448	96,253	92,525	55,631	107,156	121,689	112,163

Unlike many other northern rivers the lower Fox is rarely troubled with ice gorges, because the ice on Lake Winnebago melts gradually. It is stated that trouble is sometimes experienced from anchor ice forming on the rapids in exceptionally cold weather, but this is largely prevented by the system of slack-water navigation.

The absence of great freshets prevents backwater and allows the construction of the mills out into the stream, as well as connecting sidetracks on short trestles only a few feet above the water, with perfect safety.

The bed of the river in nearly all cases is in hard limestone. Excellent quarries of fine building stone have been opened for use in both the Government and private improvements of the river.

Water Powers.

GENERAL STATEMENT.

No other river system in the State has so large a proportion of its total descent concentrated in its lower reaches as has the Fox. Between Lake Winnebago and Green Bay the river descends a total of 166.7 feet in a series of eight rapids. The total drainage area of the river is 6,449 square miles, of which area 6,046 square miles or 94 per cent, are included above the outlet of Lake Winnebago. These two facts—the large concentration of fall in the lower river and the location of 94 per cent of its drainage area above this concentration—have the effect of producing extensive and valuable water powers.

"Before any improvements had been made the river flowed between wooded clay bluffs from 10 to 70 feet or more in height, in some places rising abruptly from the river's edge on each side. Through this channel ran the clear, dashing river over its limestone bed from 300 to 1,000 feet wide. Great changes have since been made."[1]

The following table gives the location and amount of fall at each of these rapids before improvement, according to surveys of Major Suter in 1866:

[1] Tenth Census.

Rapids on lower Fox River in 1866 (before improvement).[1]

Name.	Descent.	Distance apart.
	Feet.	*Miles.*
Depere	8	.....
Little Kaukauna	8	6.0
Rapide Croche	8	6.0
Grand Kaukauna	50	4.5
Littlechute	38	2.5
Cedar rapids	10	.75
Grand Chute	38	4.0
Winnebago Rapids	10	4.25
Green Bay to Lake Winnebago	170	28.0

LEGAL STATUS.

In 1846 Congress passed an act granting a large amount of land to the State of Wisconsin for the purpose of making a navigable route from Lake Michigan along Fox River to Wisconsin River. In 1853 the State, after expending $400,000 upon the improvements, passed the whole matter, including the land, into the hands of the Fox and Wisconsin Improvement Company. This company issued bonds, completed the improvement, and in 1856 the first steamer passed through from Mississippi River to Green Bay. On the advent of railroads soon after, the route fell into disuse, and the company was unable to pay interest on its bonds. Suit was brought by the holders of these bonds, and the franchises, property, and land grants of the company were sold to a corporation organized in 1866 as the Green Bay and Mississippi Canal Company. In 1870 the United States appraised the value of the locks and canals at $145,000, took possession of them on the payment of this sum, and has since exercised control in the interests of navigation.

The Green Bay and Mississippi Canal Company still exists and retains its land grants, water-power franchises, and other property. The company claims the right to all surplus water after the needs of navigation are supplied. This claim includes the right to tap the canals at any point and draw off the water, provided navigation is not interfered with, as well as the right to take all the surplus flow of the river at the head of each rapids and use it at that level. This claim has been confirmed by the United States Supreme Court. The

[1] Warren, G. K., Report, 1876, p. 29.

company does not claim ownership of power which is developed at a level below the head of a rapids by persons owning the land and using water which has passed the tailraces of the company.

In some cases this company owns the power, while others own the land. These interests have in some instances been mutualized in a joint company; in others protracted lawsuits have resulted in preventing the development and use of the water power up to the present time. The water powers at Rapide Croche and Little Kaukauna dams have not been improved for this reason.

As the low-water flow of the river falls far short of being sufficient for the turbines now installed, frequent controversies and lawsuits concerning the ownership of the water have resulted. Finally a few years ago the Neenah and Menasha Water Power Company, composed of practically all the users of water for power purposes on the river, was formed to regulate the use of the surplus water not required for navigation. Under the rules of the Secretary of War water may not be drawn below the crest of the Menasha dam except by his special permit. Such permission is frequently given, however, to help out the great manufacturing interests concerned.

Fox River discharges from Lake Winnebago in two nearly parallel channels, distant about three-fourths of a mile from each other. These branches join in less than 2 miles in Lake Butte des Morts, an expansion of the river 3 miles long and extending at right angles to the general direction of the river.

Menasha and Neenah are located at the lower end of the two channels, Menasha on the north side of the northern channel and Neenah on the south side of the southern channel. These cities are about 1 mile apart and have a total population of about 12,000.

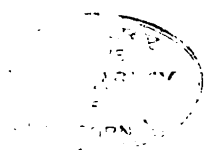
The river banks are here only 10 feet or less high. There is a dam in each channel, with an average head of 8 feet, the two maintaining the level of Lake Winnebago. These dams would develop 2,400 theoretical horsepower.[1] A view of the Government dam is shown in Figure 2, Plate 2.

The riparian owners on the Neenah channel improved the water powers before the ship canal was begun, and thus obtained a prior right under a State charter. Most of the manufactories are located on the strip of land, averaging 125 feet wide, between the river and the race.

[1] This estimate is based on an ordinary discharge of 2,000 second-feet, equal to a run-off of about 0.43 second-feet per square mile.

Fig. 1. U. S. DAM AT KIMBERLY, WISCONSIN, FOX RIVER.
Head 9.7 feet.

Fig. 2. U. S. GOVERNMENT DAM AT MENASHA, WISCONSIN.
Head 8 feet.



NEENAH.

The Kimberly Clark Paper Company is the most extensive user of water power at Neenah, having installed 20 turbines under a head of 7½ feet, rated at 1,560 horsepower. In addition, this firm has 550 steam horsepower, all used in the manufacture of sulphite and ground wood pulp. The Neenah Paper Company has installed 11 turbines under head of 7 feet, rated at 838 horsepower, and reports an additional 750 steam horsepower, all used in the manufacture of paper. The Winnebago Paper Mills have installed turbines under a 9-foot head, rated at 854 horsepower, which is supplemented with 450 steam horsepower.

Other power users in Neenah are included in the following table:

Additional water powers at Neenah.

Owner and use.	Turbines.		Steam H. P.	Remarks.
	Head.	H. P.		
	Feet.			
Kpenger & Lachmann, flour	8.0	469	125	
Neenah Boot and Shoe Manufacturing Co.	8.0	39	12	Use steam when water is cut off.
Neenah and Menasha Gas and Electric Light Co.	7.5	199	125	
Robert Jamison, machine shop	8.0	94	10	
Wulff, Clausen & Co., flour	8.0	123	60	Burned.

MENASHA.

The Government canal is located at Menasha. This canal has a total length of about 4,320 feet, its single lock being located at the lower end near Lake Butte des Morts. This dam develops 2,487 theoretical horsepower at ordinary flow. The Federal Government entered into an agreement with certain persons under which they constructed the navigation improvements and received in return the ownership of the resulting water powers. As a consequence the Green Bay and Mississippi Canal Company has no interest in these water powers.

A dam 475 feet long at the head of the canal develops a head of 8.2 feet, though some of the turbines work under heads of 6 to 8 feet. The strip of land between the canal and river is used for the location of numerous manufacturing plants, all the power, except that of the Howard Paper Mill, being taken from the canal.

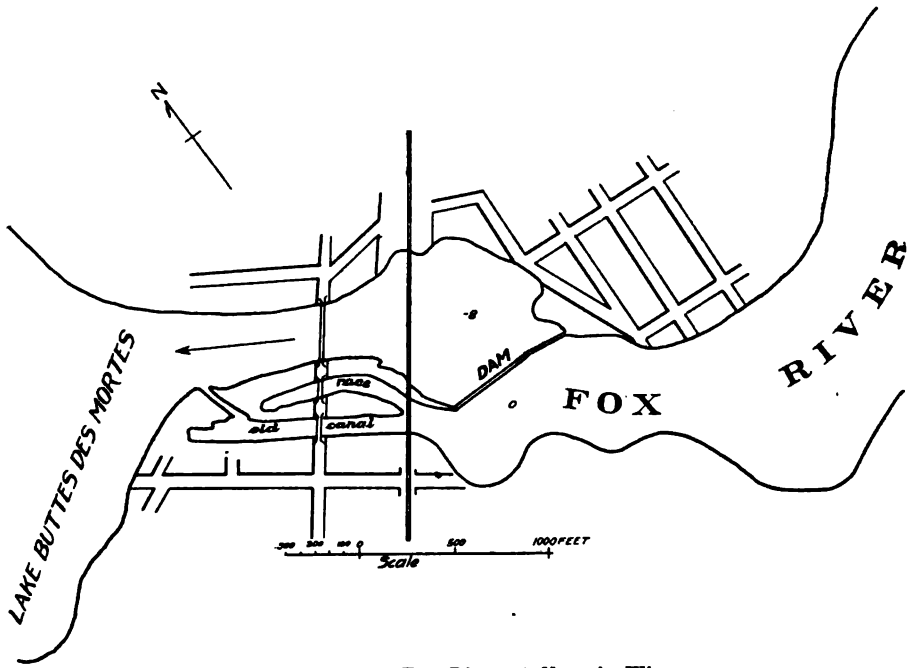


Fig. 4.—Lower Fox River at Neenah, Wis.

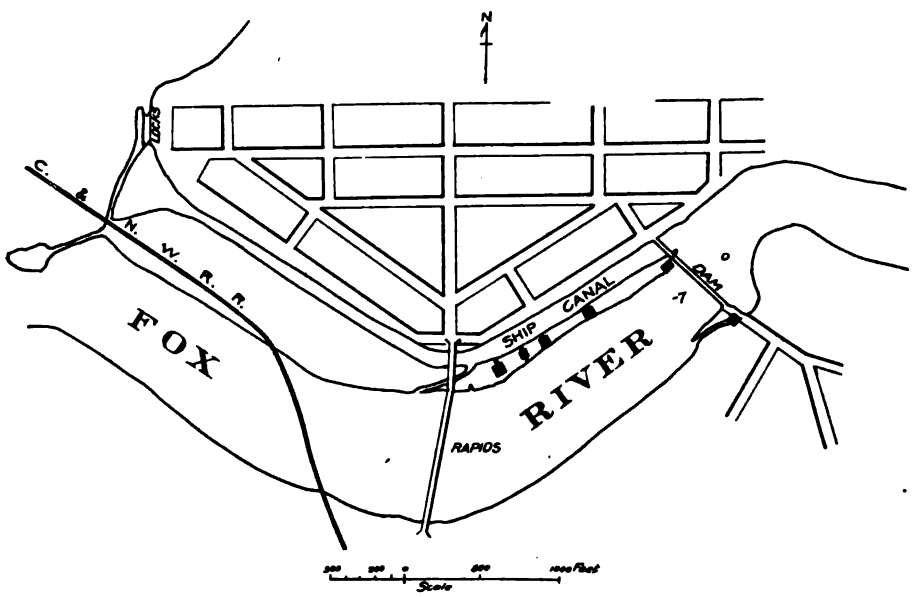


Fig. 5.—Lower Fox River at Menasha, Wis.

The largest water-power user at Menasha is the George A. Whiting Company, which owns the right to "first-class water." Its six turbines work under an average head of 8 feet and are rated at 503 horsepower. The company, which is engaged in the manufacture of paper, has also installed 265 steam horsepower.

Another large concern is the Menasha Wooden Ware Company, whose turbines work under an average head of 5 feet and are rated at 414 horsepower. This is supplemented by 1,090 steam horsepower.

The other important water-power users in Menasha are included in the following table:

Additional water powers at Menasha.[1]

Owner and use.	Turbines.		Steam H. P.	Remarks.
	Head.	H. P.		
	Feet.			
Gilbert Paper Co	5	243	800-1,000	
Howard Paper Co	5	321	200	
John Strange Paper Co	5	156	250	Leased.
Banner Flouring Mills	5	90	50	
MacKinnon Excelsior Co	6	124	225	
MacKindon Pulley Co	6	25	25	
John Schneider planing mill	6	124	.....	
Valley Knitting Co, hose, mittens, etc	4	38	.....	
Menasha Whollen Mills	5	35	Small engines.	When water is low.

For the entire distance of 5 miles between Menasha and the Appleton upper dam the river affords slack-water navigation; indeed it has been claimed that later improvements on the Appleton dam have caused the water of Menasha to back up a foot or more above its original level. As Appleton is approached the clay banks rise to a height of 50 or 60 feet.

APPLETON.

Fall.—Because of their intrinsic value, as well as on account of their early development, the Appleton powers are not excelled on the lower Fox. According to the Government profile the river has a total fall of 36.7 feet in a distance of 1.2 miles. This head is developed by three dams, which divide the river into upper, middle, and lower levels, with estimated theoretical horsepower[2] at ordinary flow of 4,238, 2,225, and 2,558, respectively.

[1] Authority, L. M. Mann, United States assistant engineer.

[2] Estimated by U. S. Asst. Engr. L. M .Mann, on flow of 170,000 minute-feet, at 4,508, 2,367 and 2,721.

At Appleton the river by a gradual bend changes its course from northeast to southeast, again turning to the northeast just above the lower dam. On the left bank the clay bluffs rise steeply 50 to 70 feet, while on the opposite bank is a flat extending for 3,500 feet, and perhaps 1,300 feet wide, beyond which rise high bluffs, as on the left bank. For the purposes of navigation the Government has constructed two dams, dividing the descent into two levels. The second or middle dam was constructed by private enterprise and is used exclusively for water power.

Upper dam.—The upper dam is a substantial stone structure. It extends from the foot of State street on the left bank normal to the shore for 250 feet, thence diagonally downstream for 700 feet to a point 400 feet from the right bank. From this latter point a retaining wall or long pier extends downstream 800 feet to the right bank. The head varies from about 10 feet at the upper end of the dam to 18 feet at the lower end, the average, as given by the Government engineers, being 14 feet. Its available water power is taken from a race along the left bank, from the ship canal on the right bank, and from the adjacent retaining wall.

The extreme variation of head is stated at 2 feet, but the ordinary variation is only half that amount. It is due to the manner of using water by the Neenah mills, and to prevalence of strong winds blowing continously on Lake Winnebago and changing volume of discharge.

The race on the left bank is 600 feet long, several extensive paper, pulp, and flouring mills occupying a strip of land between it and the river. Here are located the Appleton Paper and Pulp Company, with installed turbines under 11-foot head, rated at 550 horsepower; the Kimberly & Clark Company; the Vulcan and Tioga mills, with about 710 and 770 turbine horsepower, respectively; and the Atlas paper mill, with 766 turbine horsepower. The Appleton Waterworks Company, 1,400 feet below, receives power from this canal through a flume which affords a head of 18 feet. The above powers by long-established usage are recognized as belonging to the respective companies, and not to the Green Bay and Mississippi Canal Company.

Of the power developed on the right bank, nearly all is taken from the long pier. The Green Bay and Mississippi Canal Company owns the land on this side of the river and leases power to users.

The head here varies from 12 feet near the upper end of the pier

U. S. GOVERNMENT LOWER DAM AT APPLETON, WIS.
Head 8.5 feet.

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to 16 feet at the lower end. The water is taken through ten arched openings in the stone pier from the large bay above. This power is fully developed by the Wisconsin Traction, Heat, Light, and Power Company, with turbines under 16-foot head, rated at 2,250 horsepower (besides 2,000 steam horsepower).

Of the few unused power sites on this dam the greater number are located on the ship canal, and, as heretofore stated, are owned by the Green Bay and Mississippi Canal Company. The following table gives the developed powers:

Water powers on the United States canal at Appleton.

Owner and use.	Water power.			Steam H. P.
	Average head.	Rated H. P.	Entitled to—	
	Feet.			
Riverside Paper and Fiber Co	14.0	383	300	.....
Appleton Chair Co., furniture	7.5	26	25	35
Union Toy and Furniture Co	8.0	50	25	30

Middle dam.—The middle dam also is independent of both the Government work and the Green Bay and Mississippi Canal Company. It was built by private capital for water-power purposes only. It is 2,400 feet below the upper dam and is about 450 feet long. The dam was constructed of timber in 1877 and has its foundation in limestone. A canal leads down the north (left))bank. The south end of the dam abuts on Grand Chute Island, West's hydraulic canal being supplied from the adjacent basin.

Previous to 1877 power had been developed by wing dams passing upstream from both banks for several hundred feet. The present dam is reported to have an average head of 7.3 feet, developing at ordinary flow (2,660 second-feet) 2,190 theoretical horsepower. The head at the various factories and mills varies from 7 to 14 feet, depending on their location, the variation being similar to that at the upper dam. The water level is remarkable for uniformity.

The north-shore race is 800 feet long, supplying a head varying from 9 feet at the upper end to 12 feet at the lower.

West's canal starts at the right abutment of the dam and extends down Grand Chute Island for about 1,700 feet, nearly parallel to the river. It has a width of about 130 feet, with earth and stone embankment about 3 feet above the water surface. The head averages

10 feet. Several fine power sites still unoccupied on this canal are especially desirable because of excellent transportation facilities. Plate 3 is a view of the Fox River Paper Company's mills.

The following table gives the important users of water power from the middle dam:

Water powers on the middle dam, Appleton.[1]

Owner and use.	Water power.			Steam H. P.
	Average head.	Rated H. P.	Entitled to—	
	Feet.			
Fox River Paper Co.[2]				
Ravine mill	11.0	2,126	⅔ flow of Fox River less 25 H. P.	1,050
Lincoln mill				
Fox River mill				
Patton Paper Co.	8.0	814	1,250 H. H.	500
Patton Pulp Co				
Telulah Paper Mill, pulp	8.5	455	3,000 sq. in.	500
	14.0	903		
Appleton Machine Co	5.0	14	500 sq. in.	25
Appleton woolen mill, paper, knitting, etc.	5.0	47	90 H. P	50
Fourth Ward plaining mill, lumber	8.0	28	30 H. P.	.....
Marston & Bridge, hubs and spokes	8.0	77	75 H. P.	.....
Valley Iron works	7.0	47	40 H. P.	.....

Lower dam.—The lower or Government dam is located about three-fourths of a mile below the middle dam and just below the lower bend of the river, at a point where the river is 485 feet wide. A view of this dam is shown in Plate 4. The dam extends downstream from the left bank 417 feet, at an angle of about 45° with the channel, to an embankment which extends 600 feet farther downstream. The lower-level ship canal is back of this embankment. The river runs close to the left bank, which is high and steep, while on the right bank a flat 200 to 300 feet wide intervenes between the shore and the bluffs. There are four methods of utilizing the power—viz, from the abutment of the dam, from the race on the left bank, from the ship canal, and from the Telulah Water Power Company's canal on the right shore. The average head of this dam is stated at 8.5 feet, which at ordinary flow gives 2,550 theoretical horsepower. The report of Mr. L. M. Mann, on whose authority the above statement is made, shows that about 850 horsepower remained to be installed. There is said to be a fall of 3 feet in the 1,500 feet below the dam. This water power is owned by the Green Bay and Mississippi Canal Company.

[1] Authority, L. M. Mann, U. S. assistant engineer.
[2] Power used by Fox River Paper Co. (three mills) are located on West's canal; the other powers are on the left bank.

THE FOX RIVER PAPER COMPANY'S MILLS, APPLETON, WIS.
Middle dam.

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Fig. 1. U. S. DAM AT LITTLE KAUKAUNA, WIS. FOX RIVER or Rapid Croche

Fig. 2. LITTLE CHUTE DAM ON FOX RIVER.

The left or west-shore race starts at a point 450 feet above the dam and extends nearly parallel to the channel, a distance of 1,200 feet below the dam. The bluffs rise steeply from the water, so that mills must extend out over the river. It is claimed that this race is entitled to one-fourth of the stream flow.

The right or east canal, known as the Hyde & Harriman canal, has several good locations for mills. The land adjacent was owned by Mr. W. Hyde and Judge J. E. Harriman, while the power belonged to the Green Bay and Mississippi Canal Company. These interests were united and the canal completed in 1880. It starts at the head of the ship canal and skirts the bluffs for its entire length of 2,250 feet, leaving a wide strip of flat land between it and the river. An earth embankment forms the river side. The cross section of the canal at its upper end is 120 by 7 feet, but it gradually decreases. Its head varies but slightly and is said to average 10 feet. The most important mill on this canal is that of the Telulah Paper Company, with a total of 11 turbines, rated at 1,368 actual horsepower.

CEDARS DAM.

This dam, a view of which is shown in figure 1—Plate 2, backs up the water for the entire distance of 3.3 miles to the lower Appleton dam, affording slackwater navigation. Fox River in this stretch is hemmed in by high clay banks and has an average width of 600 feet. At a short distance below the dam however, a small creek enters from the north, causing the bluffs to recede from the river and follow up the creek, leaving a flat area of perhaps 35 acres. The dam is situated about 1,000 feet below the point where the bluffs leave the river. It crosses the river in a normal distance of 810 feet. It has an average head of 9.7 feet, which at an ordinary flow of 2,660 second-feet gives 2,910 theoretical horsepower. This power is owned by the Green Bay and Mississippi Canal Company, but the entire power is leased to the Kimberly & Clark Paper Company for a paper mill. This firm reports an installation of 33 turbines, under a head of 11 feet, rated at 4,217 actual horsepower.

LITTLECHUTE.

The next Government dam is located 4,000 feet below the Cedars dam at a small village called Littlechute. The river has extensive rapids at this point, there being a total descent, according to the

Government profile, of 36.2 feet in the 2 miles between the foot of the Cedars lock and the backwater of the Kaukauna dam below. These rapids are passed by a canal 6,500 feet long on the left bank of the river. One lock of 14.4 foot lift is located about 1,000 feet from the head of the canal, and a combined or double lock of about 21.8-foot head is located at the lower end of the canal. A view of this dam is shown in fig. 2, Plate 5.

The river is about 840 feet wide at the dam site. On the left bank the bluffs retreat from the river slightly, leaving a narrow flat and some small islands. On the right bank there is a break of perhaps 1,500 feet in the bluffs. This power and the adjacent land belong to the Green Bay and Mississippi Canal Company. The dam has a head of 12 feet, but the total available head, because of the adjacent rapids in the 7,000 feet below the dam, is stated to be 34 feet. This descent, with a flow of 2,660 second-feet, gives 10,200 theoretical horsepower. It is certain that to develop more than half this amount would require a large expenditure of money. At the present time 20 feet of fall have been developed.

The Littlechute Pulp Company has installed 24 (mostly 54-inch) turbines under a head of 12 feet, rated at 3,000 actual horsepower. The power next in importance on this dam, and the only power not leased from the Green Bay and Mississippi Canal Company, is that of a flouring mill owned by Arnold Verstigen, run by 6 turbines rated at 100 horsepower.

COMBINED LOCKS DAM.

About a mile below the Littlechute dam is the Combined Locks dam, owned by the Combined Locks Paper Company. A view of this dam, together with part of the company's plant, is shown in Pl. II, *B*. The company has 49 turbines installed, rated at 4,438 practical horsepower, leased from the Green Bay and Mississippi Canal Company.

GRAND KAUKAUNA DAM.

A descent of 50.3 feet in a distance of less than a mile entitles the Grand Kaukauna rapids to first place in all the water powers of the lower Fox River. Both topographic and transportation conditions are very favorable for improvement. The Kaukauna dam is distant 2.5 miles from the Littlechute dam and produces slack

Fig. 1. COMBINED LOCKS DAM ON LOWER FOX RIVER AT LITTLE CHUTE.
Private dam; plant cost $1,250,000.

Fig. 2. DAM ON LOWER FOX RIVER AT DEPERE.

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water to the end of the Littlechute canal. The rapids are passed by a ship canal 7,400 feet long extending from the dam and including 5 locks with an aggregate lift of 50.3 feet, all located on the left bank of the river. At its middle point this canal is distant 1,000 feet from the river. The river is about 700 feet wide at the dam, but a quarter of a mile below broadens out between several islands to a maximum width in the middle of the rapids of over 2,000 feet. The islands are low, but all have the limestone base. These islands, together with the flats on both sides of the river, give fine facilities for water-power development. The distance across the valley from bluff to bluff is about 3,500 feet.

The water powers are made available in three or more ways, viz., from the ship canal, from the Kaukauna Water Power canal, and from the Edwards & Mead canal. There is a frontage of 900 feet or more on the upper level of the ship canal suitable for power development and furnishing an average head of about 16 feet. The Kaukauna Water Power canal starts 400 feet above the dam, thence runs 400 feet at an angle from the shore of about 45°. At a point about 200 feet from the river it turns and runs parallel to the south channel of the river for 2,000 feet. Its greatest width, 150 feet, is at the bulkhead. Its minimum width is 86 feet and its depth is 11 feet. There is said to be a descent of 2 feet in the total length of 2,400 feet, the average head furnished is 18 feet. Along the side and end of the canal there is a total frontage of 2,100 feet available for power sites and mills.

The Kaukauna Water Power Company's claims to one-half the flow of the river were denied by the Green Bay and Mississippi Canal Company at the time of the construction of these improvements, and the matter was taken into the courts for adjudication. After successive trials in the State courts the question was finally settled by the United States Supreme Court October, 1898, in favor of the Green Bay and Mississippi Canal Company, which thereupon purchased the entire plant and canal of the Kaukauna Water Power Company.

In this decision the Supreme Court held broadly that the use of the surplus waters created by the Government dam and canal at Kaukauna belonged to the Green Bay and Mississippi Canal Company, but that "after such water had passed over the dam and

through the sluices and had found their way into the unimproved bed of the stream, the rights and disputes of the riparian owners must be determined by the State court."

The Edwards & Mead canal was built under the direction of Capt. N. M. Edwards, engineer for the Green Bay and Mississippi Canal Company. Advantage was taken of a branch of the main north channel running between two large islands; this was formed into a pocket by damming the ends and sides. This channel starts 600 feet below the bridge, and the dam was placed 1,000 feet below its head. As the water is taken from below the first level of the rapids the Green Bay and Mississippi Canal Company could make no legal claim to it, but subsequent to its development bought the power. The sides of the channel are substantially built of earth on the south side and dry rubble masonry on the north side.

Recently very comprehensive plans have been prepared for the improvement of the lower level at Kaukauna, which will produce 6,500 theoretical horsepower. These plans include the blasting out of the tailrace so as to develop a 21-foot head at the present Government dam, and also the construction of a new masonry dam below which will develop 27 feet additional. As this dam would render useless some of the present improvements below the Government dam, it will be ncessary to purchase such property before the new dam can be constructed. These developments will be made as soon as a suitable tenant is found.

At the present time the Green Bay and Mississippi Canal Company offers for rent 3,000 theoretical horsepower already developed at the headrace of the Kaukauna Water Power Company's canal, recently purchased. Large store buildings at this point, though partially destroyed by fire, could readily be converted into a large manufacturing plant.

The city of Kaukauna has 5,000 inhabitants and is on the main line of the Chicago and Northwestern Railway, being also reached by the Fox River Valley Electric Railway.

The following table gives a list of the power users at Kaukauna and the installed turbine power:

Water powers on Fox River at Kaukauna.[1]

Owner.	Water power.			Steam H. P.
	Average head.	Rated H. P.	Entitled to—	
	Feet.			
Badger Paper Co.	16	1,230	.....	450
Chicago and Northwestern Rwy. shops	7	47	75	110
Kaukauna Fiber Co.	14	194	100	200
Kaukauna Machine Co.	14	250	75	15
Kaukauna Electric Light Co.	14	194	.....	160
Thilmany Pulp and Paper Co.	14	389	275	175
Western Paper Bag Co.	15	1,400	400	310
Outagamie Paper Co.	21	816	1,500	.....
Lindauer Pulp Co.	12	.....	.....	.....
Reese Pulp Co.	12	440	.....	350
Thilmany Pulp and Paper Co	12	709	.....	567

[1] Nos. 1-4 are owned jointly by the Green Bay and Mississippi Canal Company; Nos. 5-9 are leased from the same company; Nos. 10 and 11 are leased from same company and Edwards.

Below Kaukauna Rapids the river is from 1,200 to 2,200 feet wide for nearly 2 miles, but it gradually contracts to a width of about 500 feet for the lower half of its course between Kaukauna and Rapide Croche. Almost without exception the bluffs rise directly from the river for the entire distance. Navigation is also by slack water from the Grand Kaukauna Canal to the Rapide Croche dam.

RAPIDE CROCHE DAM.

The Rapide Croche dam is located 4.5 miles below the Grand Kaukauna dam and was built by the Government for navigation purposes. It is about 450 feet long and has an average head of 8.5 feet. The bluffs rise on either side close to the river, except on the left bank at the site of the ship canal. This canal starts just above the dam and extends downstream for a distance of 1,760 feet to the lock. This forms a strip of land well suited for power or mill sites, being 900 feet long and varying in width from 20 feet at the ends to 200 feet at the middle. This ground and 120 acres adjacent is owned by the Green Bay and Mississippi Canal Company.

The Rapide Croche dam develops 2,400 theoretical horsepower, which may be leased on extremely favorable terms. At the present time this power is not utilized. Its location, nearly midway between Green Bay and Appleton, is convenient for the development of

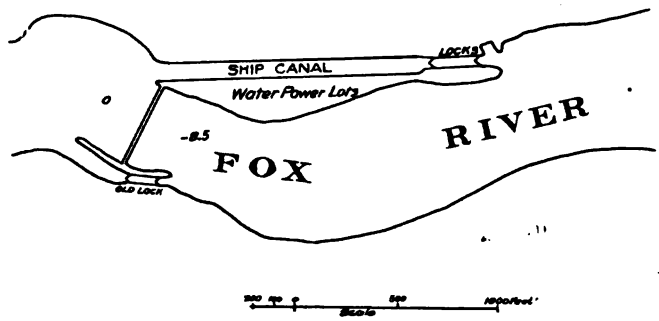

Fig. 6.—Lower Fox River at Rapide Croche, Wis.

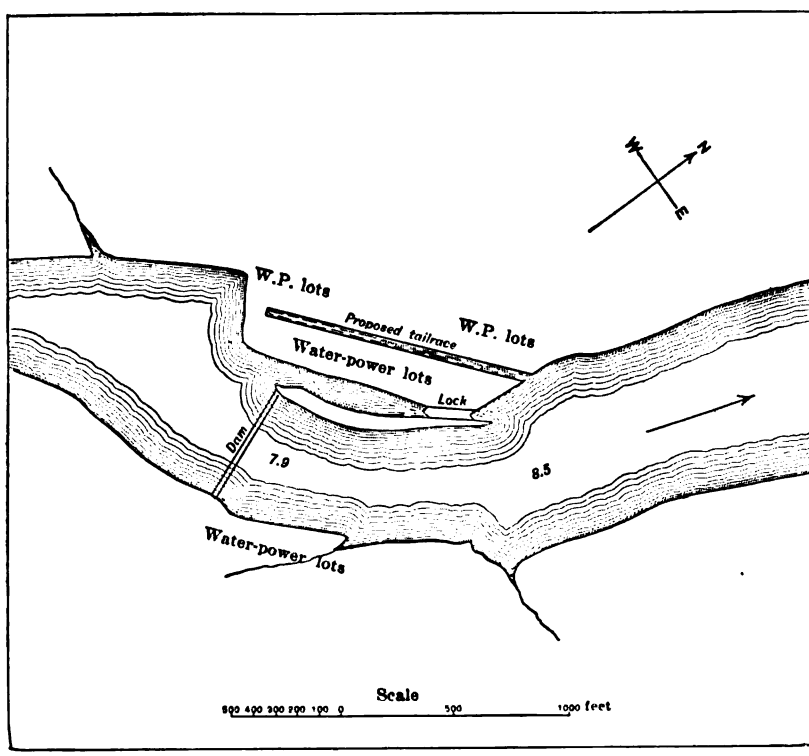

Fig. 7.—Plan of water-power development at Little Kaukauna, Wis.

electric power for railroad or other purposes. The Chicago and Northwestern Railway and the Fox River Valley Electric Railway are close at hand on the left bank.

LITTLE KAUKAUNA DAM.

Six miles below the Rapide Croche dam is located another Government dam which furnishes slack-water navigation in this stretch of the river. This dam, a view of which is shown in Pl. 5, fig. 1, is about 550 feet long and furnishes a head of 8 feet. The bluffs rise close to the right bank, but on the left bank recede for several hundred feet. Advantage is taken of this fact to locate the Government canal here. This canal is 950 feet long and has a single lock at its lower end. For details see Figure 7.

The power here, like that at Rapide Croche, is owned by the Green Bay and Mississippi Canal Company, while the riparian rights are owned by other parties. This fact has led to a protracted legal struggle, which has resulted in preventing the utilization of the valuable water powers. It is stated on good authority that these suits have recently been settled and that improvements will soon be made.

A large number of water-power lots would be made available by the construction of a tailrace parallel to the canal about as shown in fig. 3. An 8-foot head with a flow of 2,660 second-feet, gives 2,400 theoretical horsepower.

DEPERE DAM.

This dam at Depere, a city of over 4,000 inhabitants, about 7 miles from the mouth of Fox River, is the last dam and lock on the river. A view of it is shown in Fig. 2, Pl. 6. The dam is of crib construction, about 2,000 feet long, and furnishes an average head of 7 feet, which, at an ordinary flow of 2,660 second-feet, gives 2,100 theoretical horsepower. A modern steel bridge is located just below the dam.

This power does not belong to the Green Bay and Mississippi Canal Company, for it was built under a contract whereby the riparian owners were to have the use of the power in return for the maintenance of navigation improvements.

The American Writing Paper Company, which has one of the largest and most modern paper mills on the river, has installed 16

large turbines, with a rating of 1,565 practical horsepower. In addition the company uses 1,300 steam horsepower. It is entitled to the total power of the river less 290 horsepower. The value of its annual product is stated at $600,000.

On the right bank, taking water from the ship canal, are located the J. P. Dousman Company's flouring mill, with 175 actual turbine horsepower and the De Pere Electric Light and Power Company's plant, with 100 actual turbine horsepower. The flouring mill has a capacity of 300 barrels a day. These are the last powers on the river.

RAILROADS.

Attention has elsewhere been called to the fact that the freedom from the freshets which lower Fox River enjoys allows the building of railroad side tracks over or across the river so as to reach any mill no matter how situated. The river thus enjoys excellent railroad facilities. The Chicago and Northwestern Railway closely follows the left bank of the river between Neenah and Green Bay, and a branch performs a similar service for all the mills between Menasha and Kaukauna on the right bank. The Chicago, Milwaukee and St. Paul Railway reaches Neenah, Menasha, and Appleton, while another branch parallels the river between Green Bay and Depere. The Wisconsin Central line reaches Neenah and Menasha. Besides the steam lines, the river's entire length is closely followed by an electric interurban railroad, which provides a train every hour at reduced rates.

The navigation improvements maintained by the Federal Government provide for a 6-foot channel between Oshkosh and Green Bay. While this channel is insufficient for the larger freight boats navigating the Great Lakes, the commerce on lower Fox River has been sufficient to reduce the railroad freight rates to an exceedingly reasonable basis. This gives the numerous factories on this river a very marked advantage in shipping both raw materials and finished products. This advantage, together with the extremely low rates at which water power may be rented ($5 to $10 per annum per horsepower[1]), has already made this one of the largest manufacturing districts in the State.

[1] This includes the price for water delivered in fore bay only.

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MAP
OF
DRAINAGE AREA
OF
MENOMINEE RIVER
IN
WISCONSIN AND MICHIGAN
1907
SCALE

MENOMINEE RIVER SYSTEM.

This river is formed by the junction of Michigamme and Brule rivers, and for its entire length of about 104 miles forms the boundary between Wisconsin and Michigan. It flows in a general southeasterly direction, entering Green Bay at Marinette.

DRAINAGE.

The Menominee drainage basin is narrow in its lower portion, but widens as the stream is ascended, the river receiving important branches near its source. Its total drainage area is about 4,000 square miles, of which 1,450 square miles is in Wisconsin.

Like Chippewa River, it has a main arm to the north, Michigamme river, which is nearly as long as the main river, its source, in fact, being within 12 miles of Lake Superior. This has an important bearing on the discharge of the Menominee, because it secures the large run-off due to the heavy precipitation of that region as well as the steadying effect of the enlarged drainage. The combined drainage area of Brule and Michigamme rivers amounts to 1,769 square miles[1]—nearly one-half that of the entire river system.

PROFILES.

In the table that follows will be found a statement in detail of the descent of Menominee River, together with other valuable data:

[1] Tenth Census, vol. 17, p. 57.

Profile of Menominee River from its mouth to head of upper rapids, Twin Falls.[1]

No.	Station.	Distance— From mouth.	Distance— Between points.	Elevation above sea level.	Descent between points. Total.	Descent between points. Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	0.0	.....	580.0	.....	.....
2	Dam No. 1, foot	2.0	2.0	580.0	.....	.....
3	Dam No. 2, foot	2.5	.5	587.0	7.0	14.0
4	Dam No. 3, foot	2.75	.25	594.0	7.0	28.0
5	Schappies rapids, foot	7.7	5.0	612.0	18.0	3.6
6	Schappies rapids, head	8.7	1.0	622.0	10.0	10.0
7	Grand rapids, foot, (mouth of Little Cheddar River)	22.0	13.3	649.0	27.0	2.0
8	Grand rapids, head (N. W. ¼ sec. 32, T. 34 N., R. 23 E.	24.5	2.5	669.0	20.0	8.0
9	Railroad crossing, Ross	26.5	2.0	671.8	2.8	1.4
10	White rapids, foot (lot 1, sec. 30, T. 35 N., R. 21 E)	50.7	24.2	683.4	11.6	48.0
11	White rapids, head (south line sec. 7, T. 35 N., R. 22 E)	53.7	3.0	714.4	31.0	103.0
12	Pemena rapids, foot (mouth Pemena Creek)	61.5	7.8	748.3	30.3	3.9
13	Pemena rapids, head (south line sec. 5, T. 36 N., 22 E.)	63.0	1.5	767.1	18.8	12.5
14	Pemena dam, foot	67.0	4.0	773.1	6.0	15.0
15	Pemena dam, crest	67.5	.5	786.2	13.1	26.2
16	Sturgeon Falls, foot	77.0	9.5	803.9	17.7	1.9
17	Sturgeon Falls, head	77.5	0.5	816.8	12.9	25.8
18	Sturrgeon River, mouth	78.1	0.6	818.0	1.2	2.0
19	Norway, Mich. (where public road joins river)	80.1	2.0	824.0	6.0	3.0
20	Iron Mountain, Mich. (500 feet above old ferry)	84.1	4.00	851.0	27.0	6.7
21	Little Quinnesec Falls, foot	85.4	1.3	878.0	27.0	20.7
22	Little Quinnesec Falls, head	85.65	0.25	942.0	64.0	256.0
23	Big Quinnesec Falls, foot	89.9	4.25	966.0	24.0	5.6
24	Railroad bridge south of Iron Mountain	91.15	1.25	1,020.0	54.0	43.3
25	Highway bridge south of Iron Mountain	92.4	1.25	1,045.0	25.0	20.0
26	Railroad bridge, river siding	100.4	8.0	1,065.3	20.3	2.5
27	Twin Falls (500 feet below lower rapids)	101.4	1.0	1,072.5	7.2	7.2
28	Twin Falls (head of upper rapids)	102.1	0.7	1,099.8	27.3	3.9

[1] Authority: No. 1, U. S. Lake Survey; Nos. 2-6, Menominee River Boom Company; Nos. 7, 8 and 10-13, T. W. Orbison; No. 9, Wisconsin and Michigan Railway; Nos. 19-27, U. S. Geol. Survey; No. 28, Chicago and Northwestern Railway.

From its head, at the junction of Brule and Michigamme rivers, to its mouth, a distance of about 104 miles, the river descends about 700 feet. In addition to this its Wisconsin tributaries descend about 300 feet, and those in Michigan 470 feet. The opportunities for water power are numerous, because of the frequent concentrations of descent in rapids along the entire course of the river. The following descriptions of the most important water powers are taken from data furnished by Messrs. O'Keef & Orbison, hydraulic engineers, of Appleton, Wis., who also loaned maps and profiles of the river, and from the very full descriptions by James L. Greenleaf, C. E., in the census report.[1]

"It will be evident from the following account that there is an immense amount of water power on the Menominee awaiting development, the concentrations of the descent in numerous rapids and falls supplying remarkably fine opportunities for improvtments. Any works for the utilization of the power would have to be so constructed as not to interfere with the manufacturing company in the driving of logs, but dams, etc., could be built so as to be no hindrance to the passage of logs."

Geology.

While the surface is largely covered, generally deeply, by glacial drift, the Menominee and all its tributaries flow over hard, pre-Cambrian crystalline rocks as far south as the mouth of Pike River, or fully two-thirds its length. In this region important iron mines are found. Below the mouth of Pike River the Menominee flows 10 miles across the Cambrian sandstone, then for 18 miles across the next higher layer, the "Lower Magnesian" limestone, and for the last 8 miles to its mouth across the "Trenton" group of limestones.[2]

The crossing of the Cambrian sandstone results in no rapids of importance, but two rapids occur in passing the "Lower Magnesian" and the "Trenton" limestones. Most of the rapids, of course, are in the harder crystalline rocks above the mouth of Pike River.

The topography of the country through which Menominee River flows can not be described as mountainous, but many high ridges give diversity to the surface. The Wisconsin branches, Pine and Brule rivers, rise side by side with the Flambeau and the Wisconsin

[1] Water powers of the Northwest: Tenth Census, vol. 17, pp. 59-60

[2] Geol. Wisconsin.

in a high, flat plateau, abounding in lakes and swamps. In many cases the rivers head in lakes but a few rods apart, or even in the same swamp. These lakes and swamps have an elevation of nearly 1,600 feet above sea level, or 1,000 feet above Lake Michigan. The Michigan branches flow from a similar though even higher region, and it is certain that these swamps and lake reservoirs exert a marked influence in steadying the discharge of the river.

Rainfall and Run-off.

Because of the paucity of data concerning the discharge of rivers in this region, it is exceedingly difficult to estimate the ordinary discharge. The discharge measurements in this district have been made since 1901, and most of them since 1903.

The rivers mentioned below are similarly situated with respect to Lake Superior, which is perhaps the governing factor in determining the rainfall. In 1903 Escanaba River yielded a minimum of 700 second-feet from .891 square miles. Measurements made by the I. Stevenson Company indicate a minimum flow of this river, in a dry year, of 400 second-feet. Measurements of Iron River, continuing from November, 1901, to April, 1904, show a minimum flow of 0.8 second-foot per square mile for two months in 1902, and the same for February, 1903. It seems reasonably certain that except in unusually dry years the ordinary low-water discharge of these rivers is not far from 0.6 second-foot per square mile. In 1904, a year of average rainfall, the minimum run-off occurred in the month of December, when it averaged 0.77 second-foot per square mile.

In the following tables will be found the maximum, minimum, and mean discharge in second-feet of Menominee River at Little Quinnesec Falls during twelve months of 1898 and 1899:

Estimated monthly discharge of Menominee River at Little Quinnesec Falls, Wis.,[1] May, 1898, to August, 1899.

[Drainage area, 2,432 square miles.]

Date.	Discharge.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.
1898.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Inches.*
May	3,302	2,443	3,096	1.26	1.45
June	3,616	1,447	2,459	1.01	1.13
July	2,740	655	1,439	.59	.68
August	4,968	499	2,292	.94	1.08
September	3,544	797	2,566	1.05	1.17
October	5,735	1,947	3,248	1.34	1.54
November	3,601	1,484	2,766	1.14	1.27
1899.					
April	4,649	3,083	4,011	1.65	1.84
May	4,485	3,744	4,112	1.69	1.95
June	4,624	2,017	3,476	1.43	1.60
July	2,521	804	1,819	.75	.86
August	1,789	1,408	1,573	.65	.75

[1] For the daily discharge for this time see Water-Supply Paper No. 83, pp. 256-257. Measurements were made by J. H. Wallace, C. E., and furnished by Kimberly & Clark, of Niagara, Wis.

It will be seen that the smallest monthly average during this time was 0.59 second-foot per square mile of drainage. Lumbering operations on Menominee River, though declining since 1892, are still active. The operation of the many logging dams must have a great effect on the regimen of the river. In a few years the lumber will be so nearly removed that it will be cheaper to carry logs by railroad. Then the dams can be used to augment the low-water flow. This will greatly enhance the value of the water powers.

The average annual rainfall of this region is estimated by the Tenth Census at 35 inches, or 10 per cent in excess of the average of the State.

The following table gives the annual precipitation in the valleys of Wolf, Oconto, Peshtigo, and Menominee rivers for the eleven years ending in 1904:

Annual precipitation, with averages, at seven stations in Wisconsin covering eleven years.

Sta on.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Average.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	Inches.
Amherst	.....	.....	35.1	30.2	28.7	30.2	37.6	.....	32.1	.....	30.2	34.7
Koepenick	23.3	24.9	33.2	25.5	28.1	31.3	46.6	33.0	27.7	42.9	43.0	33.6
Florence	27.6	27.2	29.2	25.7	27.5	34.3	37.9	32.7	.....	43.3	.....	31.7
Oconto	29.9	29.9	36.0	28.1	29.7	26.4	38.0	26.1	29.3	34.1	34.7	31.3
New London	.....	.....	.....	27.4	29.0	.....	35.6	28.1	34.3	28.8	31.1	30.8
Shawano	27.9	.....	32.8	25.3	25.3	27.9	39.3	.....	.....	.....	.....	29.8
Waupaca	.....	.....	33.6	26.5	24.3	32.4	.....	26.0	30.8	32.0	32.0	29.7
Average	27.3	27.3	36.3	27.0	27.5	30.8	39.1	29.6	30.8	36.2	34.2	31.5

The summary given above, embodying observations of the yearly rainfall from 1894 to 1904, inclusive, at seven near-by stations, shows the average rainfall of this section for the above period to be 31.5 inches. This is very conservative, for earlier observations for longer periods show larger averages, as will be seen from the following:

Record of precipitation at two stations in Wisconsin prior to 1894.

[From Smithsonian tables.]

Station.	Period covered.	Precipitation.
	Years.	*Inches.*
Embarrass	35	38.3
Weyauwega	12	44.1

There is reason to believe that the rainfall at the headwaters of these rivers is in excess of that on the lower part of the drainage area, where most of the observation stations are located.

The following table compiled from Bulletin C, United States Weather Bureau, shows the results of observations of precipitation and temperature in the basins of Fox, Oconto, Menominee, and Wolf rivers for the years stated prior to 1876:

Record of precipitation and temperature at nine stations in Wisconsin prior to 1876.

Station.	Period of observation.	Precipitation.					Temperature.	
		Spring.	Summer.	Autumn.	Winter.	Year.	Summer.	Winter.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*°F.*	*°F.*
Wautoma	1871-1874	5.50	6.25	1.98	3.16	25.92	.....	.....
Portage	1836-1845	5.58	11.46	7.69	2.83	27.50	68.22	19.81
Weyauwega	1861-1873	6.74	17.85	14.23	5.31	44.13	68.20	19.32
Waupaca	1867-1874	5.50	14.50	6.92	3.93	25.92	70.17	20.48
Menasha	1857-1858	6.83	10.73	7.06	5.14	29.76	65.30	23.11
Appleton	1856-1871	7.65	10.24	6.92	3.70	28.51	67.48	20.15
Green Bay	1858-1865	6.18	9.35	10.43	4.46	32.42	68.10	18.69
Embarrass	1864-1874	8.14	12.49	8.21	5.73	34.57	66.89	18.25
Escanaba	1872-1876	8.52	13.72	10.57	3.28	36.09	.....	.....

It will be noted that the upper portion of this drainage area is scarcely represented in the above tables, the stations where rainfall observations were made being grouped in the lower portion of the river valleys. There is reason to believe that the average rainfall would be found to be sensibly larger for a series of stations more evenly distributed so as to include the northern portion.

The following discharge measurements, gage heights, and rating table are the result of observations by hydrographers of the United States Geological Survey on Menominee River, near Iron Mountain, Mich.:

Discharge measurements of Menominee River at Homestead bridge, near Iron Mountain, Mich., 1902 to 1907.

Date.	Hydrographer.	Width.	Area of sect.on.	Mean velocity.	Gage height.	Discharge.
1902.		*Feet.*	*Sq. feet.*	*Ft. pr. sec.*	*Feet.*	*Sec-feet.*
September 4	Horton and Gregory	.....	.....	.....	1.90	1,322
November 4	W. V. Savicki	.....	.....	.....	2.67	1,584
1903.						
April 9[1]	L. R. Stockman	202	1,533	2.22	5.40	3,409
April 19	do	.....	2,000	2.78	7.32	5,570
July 22	do	208	1,455	2.17	4.20	3,161
August 25	do	208	1,342	1.76	3.60	2,357
September 16	do	212	2,875	[2]3.41	10.38	9,490
October 27	do	205	1,477	1.93	3.99	2,856
1904.						
May 18	E. Johnson, jr	210	2,312	2.68	7.95	6,193
June 1	do	210	2,523	3.01	8.97	7,591
August 10	do	205	1,101	1.42	2.06	1,558
September 5	do	210	1,571	2.02	4.34	3,176
October 11	F. W. Hanna	223	2,408	3.20	8.25	7,714
November 18	E. Johnson, jr	210	1,511	1.94	4.02	2,925
1905.						
April 12	S. K. Clapp	220	2,271	2.90	7.43	6,588
May 22	do	215	2,035	2.32	6.85	4,718
June 15	M. S. Brennon	208	1,421	1.78	3.67	2,524
July 13	do	225	2,100	2.50	6.58	5,230
August 13	do	207	1,346	1.83	3.24	2,469
1906.						
April 18	A. H. Horton	244	3,213	3.40	11.51	10,911
April 18	M. S. Brennen	244	3,247	3.46	11.67	11,244
June 8	do	238	2,958	2.96	10.45	8,753
June 9	do	238	2,824	2.84	9.92	8,032
1907.						
April 18	A. H. Horton	216	2,266	2.63	7.61	5,960
June 20	G. A. Gray	205	1,214	1.57	2.98	1,942
August 22	do	208	1,462	1.67	4.00	2,490
October 16	do	207	1,281	1.74	3.18	2,278
Dec. 17[3]	do	195	995	1.25	2.2	1,270

Velocity obtained by floating ice.

[1] Affected by log gain.

[2] Mean velocity=85 per cent of surface velocity.

[3] Dec. 17 measurement taken under half open and half frozen conditions.

Mean daily gage height, in feet, of Menominee River near Iron Mountain, Mich., September 4, 1902, to December 31, 1907.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1	.....	1.67	2.52	1.60	17	1.40	1.65	6.45	2.55
2	.....	1.53	2.80	2.22	18	1.45	1.92	5.65	2.70
3	.....	1.55	2.95	2.80	19	1.35	1.60	5.35	2.63
4	1.90	1.45	2.72	2.25	20	1.35	1.65	5.00	2.75
5	1.60	1.55	2.85	1.95	21	1.20	1.57	4.47	2.75
6	2.00	1.58	2.95	1.95	22	1.45	1.65	4.45	2.57
8	2.35	1.67	2.60	2.70	23	1.52	1.67	3.90	2.40
7	2.25	1.60	2.50	2.25	24	1.48	2.42	3.92	2.32
9	2.05	1.77	2.50	3.45	25	1.47	2.80	3.45	2.35
10	1.92	1.30	2.40	3.35	26	1.40	3.22	3.30	2.20
11	1.87	1.50	2.45	3.60	27	1.40	2.95	3.00	2.10
12	1.95	1.55	3.27	3.35	28	1.35	3.57	2.62	2.00
13	1.65	2.85	4.85	3.05	29	1.38	3.07	2.55	2.15
14	1.53	2.95	6.07	2.90	30	1.55	2.83	2.62	2.20
15	1.45	2.47	6.88	2.85	31	.....	2.75	.....	2.10
16	1.40	1.82	6.57	2.90					

Mean daily gage height, in feet, of Menominee River near Iron Mountain, Mich., September 4, 1902, to December 31, 1907—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.												
1	2.55	2.35	2.38	4.68	7.95	9.30	3.70	6.25	4.45	4.30	3.80	3.60
2	2.52	2.30	2.38	5.15	7.85	8.05	4.80	6.20	4.05	4.40	3.80	3.65
3	2.42	2.20	2.42	5.65	9.55	6.30	6.50	4.55	3.70	5.20	3.75	3.55
4	2.48	2.15	2.40	6.35	8.80	7.60	3.85	5.60	3.50	6.60	4.10	3.55
5	2.50	2.15	2.35	2.25	9.45	7.05	3.50	6.60	3.65	7.70	4.00	3.70
6	2.30	2.28	2.48	4.75	9.48	6.50	7.40	8.00	4.00	7.50	3.80	3.60
7	2.25	2.25	2.55	8.30	9.72	3.40	6.30	9.00	4.65	7.65	3.50	3.40
8	2.40	2.22	2.68	5.50	9.60	4.85	5.95	8.90	5.70	7.55	3.65	3.35
9	2.35	2.20	2.72	5.50	9.32	4.85	5.45	7.20	6.65	7.10	3.50	3.35
10	2.30	2.28	2.72	6.05	7.90	4.45	5.25	6.70	6.90	6.85	3.40	3.05
11	2.35	2.40	2.75	6.25	8.98	3.90	5.20	6.75	5.80	6.70	4.10	2.90
12	2.30	2.28	3.00	7.25	8.10	3.50	6.00	6.60	5.50	6.50	4.95	2.60
13	2.20	2.22	3.32	7.15	9.90	4.40	4.65	6.50	7.60	6.25	3.50	2.50
14	2.10	2.25	3.55	6.70	9.45	6.75	4.60	5.40	8.10	5.75	3.20	2.40
15	2.18	2.20	3.50	7.45	9.18	4.50	4.00	5.60	9.00	5.50	3.25	2.45
16	2.22	2.25	3.48	7.52	8.65	4.45	3.40	5.60	10.50	5.40	3.55	2.40
17	2.25	2.22	3.55	7.55	7.60	4.55	3.05	3.70	11.20	4.85	3.25	2.40
18	2.25	2.18	4.25	7.80	6.22	4.80	2.75	4.05	10.40	4.90	2.85	2.35
19	2.32	2.20	6.25	8.30	7.55	3.75	2.85	4.25	9.45	4.60	2.65	2.65
20	2.25	2.18	8.38	7.45	8.72	4.80	2.40	4.05	8.70	4.90	2.85	2.35
21	2.10	2.10	8.85	7.58	9.05	2.30	3.10	3.75	8.00	5.20	2.50	2.30
22	2.20	2.00	7.50	7.05	7.40	3.10	4.20	3.70	6.85	5.30	3.25	2.35
23	2.22	1.95	6.20	6.90	9.40	2.70	3.15	3.75	6.95	4.35	3.00	2.35
24	2.15	2.20	5.95	7.65	6.80	3.10	3.10	3.75	6.35	4.20	3.10	2.30
25	2.12	2.25	5.80	7.50	7.80	2.80	3.25	3.35	5.90	4.05	2.90	2.35
26	2.25	2.32	6.15	7.75	7.15	2.00	4.30	4.05	4.45	3.80	3.00	2.65
27	2.35	2.45	5.42	7.00	8.45	3.80	5.30	4.65	5.50	3.90	2.85	3.15
28	2.25	2.38	5.50	6.45	10.40	2.70	5.70	3.85	4.80	3.85	3.00	3.25
29	2.35	.....	5.15	6.82	11.85	2.45	6.85	3.90	4.40	3.80	3.10	3.10
30	2.35	.....	4.65	7.45	10.10	2.00	8.20	4.00	4.00	3.75	3.60	3.05
31	2.20	.....	4.30	.....	10.75	.....	7.10	4.55	.....	3.70	.....	3.15

Mean daily gage height, in feet, of Menominee River near Iron Mountain, Mich., September 4, 1902, to December 31, 1907—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	.....	4.30	4.75	4.65	7.90	8.45	4.60	2.35	1.80	3.05	3.10	2.42
2	.....	4.25	4.70	4.55	7.95	6.95	2.35	3.30	3.15	2.75	3.65	2.20
3	3.20	4.30	4.55	4.35	8.70	5.65	2.20	2.90	3.70	2.65	4.10	2.22
4	2.90	4.50	4.10	4.60	9.70	6.30	2.90	3.00	4.95	2.45	3.75	2.25
5	2.70	4.30	3.90	5.10	8.15	9.60	2.80	1.30	4.30	2.75	3.25	2.55
6	2.75	4.25	4.50	4.85	9.70	7.30	3.70	2.70	4.00	2.85	3.50	2.50
7	2.75	4.20	4.90	4.70	8.50	8.80	3.60	1.30	4.10	2.55	3.80	2.30
8	3.20	4.20	4.80	4.65	10.40	7.50	3.60	1.20	4.10	2.90	4.85	2.92
9	3.60	4.25	4.70	6.05	11.95	8.55	4.20	1.45	3.70	3.80	4.10	2.95
10	3.50	4.00	3.95	6.20	(1)	8.50	3.30	3.20	3.15	6.70	3.10	2.97
11	3.45	3.90	3.50	4.10	11.80	7.50	4.10	3.80	2.90	7.60	3.20	2.75
12	3.20	3.95	3.00	3.80	11.10	6.70	4.20	4.40	3.10	8.25	3.20	2.50
13	3.10	3.90	3.15	3.65	10.70	6.70	1.80	4.00	2.55	7.80	3.25	2.32
14	3.40	3.85	3.30	3.70	10.55	5.90	4.30	1.90	2.85	7.35	3.05	2.27
15	4.25	3.95	3.25	3.75	9.65	5.40	3.75	2.05	3.50	6.40	2.95	2.33
16	4.30	3.80	3.00	4.10	9.05	4.95	4.30	3.70	3.40	5.90	3.05	2.32
17	4.30	3.75	3.05	3.95	8.10	4.60	1.65	3.60	2.80	5.55	2.80	2.47
18	4.35	3.75	3.35	4.25	8.15	4.50	3.25	4.00	3.15	5.30	3.85	2.50
19	4.35	3.70	3.45	4.40	8.15	3.70	3.05	3.10	2.60	5.20	3.15	2.47
20	4.40	3.90	3.15	4.30	6.25	3.50	2.50	3.15	2.70	5.00	2.92	2.27
21	4.15	3.75	3.15	4.35	4.90	3.50	4.30	3.40	2.95	5.00	2.90	2.23
22	4.10	3.60	3.40	4.40	6.15	4.40	2.70	3.65	2.39	5.05	2.67	2.42
23	4.25	3.60	3.45	5.45	6.10	3.70	2.30	3.45	2.55	5.05	2.77	2.37
24	4.25	3.55	3.75	6.05	7.05	3.70	1.30	3.90	3.80	5.15	2.85	2.40
25	4.20	3.65	4.55	7.35	8.25	5.45	2.75	3.90	3.90	5.05	2.75	.....
26	4.20	3.55	4.60	7.25	9.60	7.20	1.40	3.40	3.95	5.15	2.42	2.47
27	4.25	3.75	4.35	7.45	(1)	6.75	2.70	2.70	4.15	5.05	1.92	2.32
28	4.20	4.55	4.40	8.35	10.90	5.60	1.50	2.30	4.00	4.85	1.75	2.20
29	4.50	4.90	4.30	7.75	10.00	6.70	3.10	1.90	3.50	4.35	2.00	(2)
30	4.45	.....	4.55	7.40	8.70	6.70	1.45	3.05	3.37	4.30	3.07	.....
31	4.35	.....	4.60	.....	8.00	.....	1.30	1.95	.....	3.90	.....	2.60
1905.												
1	2.60	.....	2.35	7.40	8.60	3.60	5.50	4.20	2.80	2.82	3.30	1.80
2	2.58	.....	2.38	6.80	8.40	5.60	8.60	3.70	3.90	2.80	3.30	1.75
3	.....	.....	2.45	6.70	8.50	2.40	6.40	3.40	7.20	2.50	3.20	2.25
4	.....	.....	.....	7.00	9.10	2.40	7.10	3.50	8.00	2.42	3.00	2.30
5	2.35	.....	.....	7.90	9.20	3.50	8.00	3.40	7.80	2.42	3.00	2.25
6	2.60	2.70	.....	8.00	9.20	6.30	8.00	3.45	7.00	2.35	3.00	2.65
7	2.60	.....	.....	7.45	9.30	6.90	7.60	3.30	6.30	2.40	2.95	3.30
8	2.80	.....	2.60	6.80	9.20	7.30	7.60	3.25	5.30	2.42	2.88	3.15
9	2.82	.....	2.62	6.80	9.80	6.30	5.80	3.40	4.60	2.40	2.92	3.20
10	.....	.....	2.60	6.60	9.60	7.10	4.20	3.30	4.40	2.35	3.00	3.20
11	.....	.....	.....	7.00	9.10	5.20	5.20	3.40	4.10	2.40	3.00	3.30
12	.....	.....	.....	7.30	9.00	5.80	4.90	3.20	3.70	2.45	3.00	3.20
13	.....	2.40	.....	7.40	9.10	5.70	5.40	3.20	3.35	2.50	2.90	3.45
14	.....	.....	.....	7.40	8.30	5.70	5.20	3.30	3.00	2.55	2.98	3.30
15	.....	.....	2.38	6.70	7.40	5.80	5.60	3.30	2.95	2.80	3.10	3.25
16	3.20	.....	2.30	6.40	8.60	6.40	4.30	2.80	3.60	2.90	3.15	3.40
17	.....	.....	2.22	6.10	9.70	7.30	4.40	2.50	4.30	2.82	3.05	3.30
18	2.90	2.55	2.25	6.20	10.10	7.20	6.10	2.65	4.40	2.98	2.90	3.25
19	2.92	.....	2.35	5.80	10.20	10.20	3.90	2.50	4.80	3.10	2.88	3.00
20	2.95	.....	2.50	5.80	9.30	9.30	3.40	2.70	4.90	3.30	2.90	2.95
21	2.78	2.35	2.40	5.70	10.20	6.70	2.20	2.72	4.80	3.50	3.05	2.85
22	2.75	.....	2.45	6.00	7.40	8.40	2.05	2.25	4.40	3.50	3.05	2.70
23	2.50	.....	2.50	6.20	7.40	6.50	2.95	2.00	3.80	3.50	3.10	2.60
24	.....	.....	2.65	6.00	7.40	6.50	3.90	2.22	3.50	3.50	3.05	2.60
25	.....	2.35	2.98	5.80	6.00	5.80	3.70	2.28	3.45	3.55	3.15	2.62
26	.....	2.40	3.40	6.40	5.20	5.60	3.70	2.20	3.15	3.50	3.20	2.65
27	.....	2.40	3.80	6.80	7.60	7.80	3.40	2.28	2.95	3.40	3.05	2.70
28	.....	2.45	4.60	7.60	5.60	7.60	3.95	2.10	3.05	3.20	2.90	2.55
29	3.00	.....	6.00	8.00	4.80	8.00	4.60	2.12	2.85	3.20	2.50	2.40
30	.....	.....	7.60	8.60	5.80	8.90	4.70	2.07	2.80	3.20	1.80	2.40
31	.....	.....	7.40	.....	3.40	.....	4.60	2.00	.....	3.30	.....	2.48

[1] Gage under water.

[2] River frozen.

Daily gage height, in feet, of Menominee River at Iron Mountain, Mich., September 4, 1902, to December 31, 1907—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1906.										
1	2.48	4.55	3.0	3.8	8.5	8.8	9.2	2.7	2.6	2.9
2	2.42	4.1	3.0	3.9	9.0	6.8	8.3	2.9	3.0	2.25
3	2.4	4.0	2.95	4.3	9.4	7.0	7.5	2.65	3.1	2.3
4	2.5	4.05	2.9	4.75	9.5	5.1	8.6	2.4	2.8	2.4
5	2.5	4.0	2.8	4.9	9.8	7.0	6.4	2.7	2.65	2.5
6	2.6	3.9	2.82	4.92	9.1	6.0	6.2	3.75	2.5	2.45
7	2.58	3.8	2.9	5.0	8.2	8.4	4.1	4.25	2.3	2.4
8	2.5	3.75	2.82	5.05	8.5	10.7	4.0	4.0	2.4	2.5
9	2.4	3.6	2.9	5.35	7.6	11.3	3.6	3.8	2.6	2.6
10	2.4	3.55	2.9	6.1	7.3	10.3	4.75	3.5	2.1	2.55
11	2.3	3.4	3.0	7.15	7.8	8.1	4.4	3.2	2.0	2.75
12	2.4	3.4	3.05	7.9	7.1	7.7	4.3	3.3	2.4	2.65
13	2.85	3.42	3.1	8.25	7.2	6.7	3.9	2.75	4.0	2.7
14	3.45	3.4	3.0	8.9	6.1	4.6	4.1	2.4	3.9	2.75
15	3.6	3.3	3.0	10.6	6.2	3.7	4.6	2.5	3.7	2.4
16	3.6	3.25	3.0	11.05	6.5	4.6	4.3	2.6	3.9	3.25
17	3.5	3.25	2.95	11.4	6.3	2.9	4.1	4.1	3.7	4.05
18	3.35	3.20	2.9	11.7	6.7	2.4	3.8	3.8	3.4	4.15
19	3.0	3.35	3.0	13.1	6.2	2.3	3.6	3.1	3.1	5.0
20	2.7	3.4	2.95	13.7	5.3	3.3	4.2	2.9	2.9	[1]
21	2.7	3.3	2.95	14.3	5.15	4.8	3.9	2.6	2.75	.....
22	2.8	3.3	3.05	14.1	4.35	4.75	3.4	2.85	3.0	.....
23	2.75	3.25	3.05	13.2	2.3	4.3	4.2	3.2	2.9	.....
24	2.8	3.25	2.95	12.15	4.5	4.2	3.9	3.6	2.8	.....
25	3.2	3.20	2.9	11.9	4.7	3.0	3.8	3.9	2.7	.....
26	4.15	3.25	3.05	10.7	5.5	2.6	3.2	4.1	2.65	.....
27	4.85	3.2	3.3	10.1	7.0	8.35	3.8	3.8	2.8	.....
28	5.3	3.05	3.4	9.6	6.7	9.0	3.6	3.6	2.75	.....
29	5.0	.....	3.45	9.4	7.7	8.8	3.4	3.5	2.7	.....
30	4.8	.....	3.55	9.2	8.3	9.1	3.0	3.25	2.8	.....
31	4.8	.....	3.6	.....	8.9	.....	2.8	2.8	.....	.....

[1] Gage reader left.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.										
1	.....	7.3	7.6	8.5	5.9	1.3	1.6	3.4	2.4	1.8
2	.....	7.0	7.8	8.0	1.9	1.6	1.2	3.3	2.4	1.8
3	.....	7.3	8.4	7.8	6.1	1.5	1.35	3.2	2.6	1.9
4	.....	7.7	9.6	7.6	5.8	1.5	1.6	3.3	2.8	1.9
5	.....	7.6	9.6	8.3	5.3	1.2	1.6	3.3	2.5	2.1
6	.....	7.3	9.8	7.6	4.5	1.1	2.0	3.3	2.45	2.2
7	.....	7.5	9.8	5.2	4.5	1.3	2.0	3.3	2.5	3.0
8	.....	7.6	10.2	5.3	4.2	1.4	1.9	3.1	2.5	3.0
9	.....	7.3	10.4	5.3	4.1	1.4	1.8	3.6	2.5	3.0
10	.....	6.9	8.5	5.4	3.7	1.8	1.7	3.5	.....	2.8
11	.....	6.6	9.4	5.8	3.6	1.7	1.7	3.4	.....	2.5
12	.....	6.5	9.5	4.7	2.2	1.6	1.9	3.5	2.1	2.1
13	.....	6.3	9.7	3.2	4.7	1.9	1.9	3.5	1.9	2.1
14	.....	6.1	10.3	2.9	4.7	1.7	1.8	3.6	1.6	2.2
15	.....	6.0	13.3	4.0	4.6	1.6	2.0	3.2	1.7	2.3
16	.....	5.9	14.1	3.2	3.5	1.5	2.0	3.2	1.8	2.3
17	.....	5.8	14.7	2.6	2.6	1.6	2.3	3.3	2.0	2.3
18	.....	5.8	14.3	2.9	3.7	1.6	2.3	3.0	2.4	2.3
19	.....	5.7	12.7	3.6	2.1	1.8	3.8	2.8	2.2	2.4
20	.....	5.6	13.0	3.0	1.9	1.8	4.6	2.8	2.1	2.5
21	.....	5.8	11.8	3.5	1.9	2.8	4.8	2.9	2.2	2.3
22	.....	6.1	10.9	3.8	2.1	2.6	4.8	2.5	2.4	2.3
23	.....	7.3	12.6	3.9	1.4	2.0	5.0	2.5	2.2	2.3
24	[1]3.8	8.3	11.3	3.2	1.6	3.2	5.3	2.6	2.5	2.5
25	4.3	8.5	10.0	4.5	1.3	1.7	5.3	2.6	2.9	2.5
26	4.8	8.6	10.0	4.8	1.2	3.1	5.2	2.4	2.7	2.4
27	5.25	8.9	10.0	5.6	1.6	2.9	5.0	2.8	1.8	2.3
28	6.65	9.8	9.8	6.8	1.4	2.8	4.9	3.0	1.9	2.3
29	7.2	8.6	9.7	6.2	1.4	2.6	4.4	2.4	1.8	2.3
30	7.5	7.6	9.0	6.0	1.6	2.5	3.7	2.45	1.8	2.3
31	7.5	.....	8.5	.....	1.3	1.8	.....	2.4	.....	2.3
Average	.....	7.07	10.1	4.77	.....	.....	.....	.....	.....	.....

[1] Ice went out.

Rating table for Menominee River near Iron Mountain, Mich., September 4, 1902, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	1,032	2.8	2,080	4.4	3,242	6.8	5,230
1.3	1,094	2.9	2,150	4.5	3,319	7.0	5,420
1.4	1.156	3.0	2.220	4.6	3,396	7.2	5,615
1.5	1,219	3.1	2,290	4.7	3,474	7.4	5,815
1.6	1,282	3.2	2,361	4.8	3,552	7.6	6,025
1.7	1,346	3.3	2.432	4.9	3,630	7.8	6,235
1.8	1,410	3.4	2,503	5.0	3,708	8.0	6,450
1.9	1,475	3.5	2,575	5.2	3,865	8.5	7,020
2.0	1,540	3.6	2,647	5.4	4,023	9.0	7,630
2.1	1,606	3.7	2,719	5.6	4,183	9.5	8,280
2.2	1,672	3.8	2,792	5.8	4,345	10.0	8,970
2.3	1,739	3.9	2,866	6.0	4,510	10.5	9,670
2.4	1,806	4.0	2,940	6.2	4,680	11.0	10,370
2.6	1,942	4.2	3,090	6.4	4,860	11.5	11,070
2.5	1,874	4.1	3,015	6.6	5,040	12.0	11,770
2.7	2,011	4.3	3,166	6.7	5,135		

Rating table for Menominee River near Iron Mountain, Mich., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.00	1,540	3.30	2,432	4.60	3,396	6.80	5,230
2.10	1,606	3.40	2,503	4.70	3,474	7.00	5,420
2.20	1,672	3.50	2,575	4.80	3,552	7.20	5,615
2.30	1,739	3.60	2,647	4.90	3,630	7.40	5,815
2.40	1,806	3.70	2,719	5.00	3,708	7.60	6,025
2.50	1,874	3.80	2,792	5.20	3,865	7.80	6,235
2.60	1,942	3.90	2,866	5.40	4,023	8.00	6,450
2.70	2,011	4.00	2,940	5.60	4,183	9.00	7,630
2.80	2,080	4.10	3,015	5.80	4,345	10.00	8,930
2.90	2,150	4.20	3,090	6.00	4,510	11.00	10,250
3.00	2,220	4.30	3,166	6.20	4,680	12.00	11,660
3.10	2,290	4.40	3,242	6.40	4,860	13.00	13,100
3.20	2,361	4.50	3,319	6.60	5,040	14.00	14,600

Note—The above tables are applicable only for open-channel conditions. It is based on discharge measurements made during 1902-1906, and is fairly well defined.

Estimated monthly discharge of Menominee River near Iron Mountain, Mich., September, 1902, to December 31, 1905.

[Drainage area, 2,415 square miles.]

Date.	Discharge.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.
1902.	Sec.-feet.	Sec.-feet.	Sec.-feet.	Sec.-feet.	Inches.
September (4-30)	1,772	1,032	1,295	0.536	0.538
October	2,625	1,094	1,506	.661	.762
November	5,306	1,806	2,829	1.17	1.30
December	2,647	1,282	1,909	.790	.911
1903.					
April	6,780	1,705	5.175	2.39	2.14
May	11,560	4,698	7,496	3.57	3.10
June	8,020	1,540	3,417	1.57	1.41
July	6,670	1,806	3,553	1.70	1.47
August	7,630	2,467	4.049	1.94	1.68
September	10,650	2,575	5,091	2.35	2.11
October	6,130	2,719	4,057	1.94	1.68
November	3,669	1,874	2,505	1.16	1.04
December	2,719	1,705	2,150	1.03	.890
1904.[1]					
April	8,150	2,688	3,995	1.84	1.65
May	11,770	3,630	7,879	3,76	3.26
June	8,410	2,575	4,791	3.21	1.98
July	3,306	1,094	2,196	1.05	.909
August	3,242	1,032	2,125	1.01	.880
September	3,669	1,410	2,488	1.15	1.03
October	6,725	1,840	3,650	1.74	1.51
November	3,591	1,378	2,293	1.06	.949
December	2,199	1,672	1,838	.877	.761
1905.[1]					
April	7,140	4,265	5,282	2.19	2.44
May	9,250	2,503	6,810	2.82	3.25
June	9,250	1,806	5,011	2,07	2.31
July	7,140	1,573	3,850	1.59	1.83
August	3,090	1,530	2.130	.882	1.02
September	6,450	2,080	3,284	1.36	1.52
October	2,611	1,772	2,163	.896	1.03
November	2,432	1,410	2,204	.913	1.02
December	2,539	1,378	2,065	.863	.995
1906.					
January	3,940	1,740	2,370	0.979	1.13
February	3,360	2,260	2,500	1.07	1.11
March	2,650	2,080	2,250	.930	1.07
April	15,100	2,790	8,040	3.32	3.70
May	8,670	1,740	5,610	2.32	2.68
June	10,700	1,740	5,040	2.08	2.32
July	7,890	2,080	3,500	1.45	1.67
August	3,130	1,810	2,400	.992	1.14
September	2,940	1,540	2,160	.893	1.00
October (1-19)	3,710	1,710	2,140	.884	.62

Note.—Values are rated as follows: January and March to October, fair. It is probable that ice conditions affected the flow during February and that the value given above is considerably in excess of the true value.

[1] Ice conditions January.

KOSS, MICH.

This station was established June 21, 1907. It is located on a Wisconsin and Michigan railroad bridge 1,000 feet southwest of Koss, Mich.

The general direction of the channel is straight for 1,000 feet above station and also for 3,000 feet below station. The width at ordinary stage is 300 feet broken by one pier. (Looking down stream.) The right bank is of medium height and wooded and not liable to overflow. The highest velocity is on the left side of the stream. The left bank is high and not wooded. There is an island down stream 800 feet from the station which causes the river to divide for a short distance.

Discharge measurements are made from this bridge to which the gage is attached. The initial point of sounding is at the left end of bridge directly over the inner side of bridge abutment. The zero is indicated by a red paint mark.

A standard chain gage, which was read during 1907 by Guy H. Bronoel, is fastened to the upstream side of the bridge. The length of the chain from the end of weight to the center of marker is 30.93 feet. The gage is referred to bench marks as follows: (1) Top of railroad track opposite the gage box is 28.55 feet above the datum of the gage.

Discharge measurements of Menominee River at Koss, Mich., in 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.	Remarks.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sq.-ft.*	
June 21..	G. A. Gray.....	246	1,590	2.32	8.04	3,869	Good.
July 19..	G. A. Gray.....	242	1,380	1.83	7.27	2,652	Good.
Aug. 23..	G. A. Gray.....	235	1,147	.90	6.15	1,061	Logs running.
Oct. 15..	G. A. Gray.....	280	1,543	1.82	7.35	2,953	Logs running.
Nov. 12..	G. A. Gray.....	278	1,460	1.71	7.10	2,637	

Discharge measurements of Menomonie River near Koss, Mich., in 1908.

Date.	Hydrographer.	Width.	Area of section	Mean velocity.	Gage height. Water sur.	Discharge	Av. depth of ice.	Depth of snow.
		Feet.	Sq. feet.	Ft. per sec.	Feet.	Sec.-ft.		
1908.								
January 21.....	G. A. Gray	258	1,353	1.39	7.15	1,885	1.1	No.
February 11.....	..... do	274	1,505	1.22	7.7	1,837	1.2	.5
March 10.....	..... do	283	1,349	1.30	7.85	1,754	1.75	.3
March 10.....	..... do	283	1,349	1.26	7.85	1,756	1.75	.3

Record of thickness of Ice at Koss, Winter, 1907–8.

		Feet.
1907.		
Dec. 1.	Average thickness of ice	.8
Dec. 10.	Average thickness of ice	.8
1908.		
Jan. 3.	Average thickness of ice	.8
Jan. 13.	Average thickness of ice	.9
Jan. 20.	Average thickness of ice	1.0
Jan. 27.	Average thickness of ice	1.1
Feb. 7.	Average thickness of ice	1.4
Feb. 14.	Average thickness of ice	1.2
Feb. 21.	Average thickness of ice	1.3
Feb. 28.	Average thickness of ice	1.4
Mar. 6.	Average thickness of ice	1.8
Mar. 13.	Average thickness of ice	1.6
Mar. 20.	Average thickness of ice	1.6
Apr. 11.	River opened.	

Daily Gage Height of Menominee River at Koss, Mich., for 1907.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.55	7.3	7.35	8.1	6.9	6.95
2	.....	8.04	6.6	6.1	7.4	6.9	6.8
3	.....	7.55	6.9	7.2	7.6	6.9	6.8
4	.....	7.54	6.85	6.6	7.55	7.0	7.1
5	.....	8.02	6.95	7.5	7.4	7.1	7.0
6	.....	8.02	7.75	7.5	7.2	7.15	7.0
7	.....	8.35	7.0	7.9	6.85	7.05	7.0
8	.....	7.7	6.75	6.7	6.95	7.00	7.0
9	.....	7.9	7.0	8.05	7.05	7.0	7.0
10	.....	8.15	6.75	6.6	7.0	7.0	7.0
11	.....	7.75	7.0	8.25	7.05	7.0	7.1
12	.....	7.4	6.75	8.35	7.2	7.1	7.1
13	.....	6.95	7.0	8.6	7.05	6.95	7.1
14	.....	7.55	7.75	8.25	7.05	6.7	7.0
15	.....	8.0	6.55	7.7	7.4	6.7	7.0
16	.....	7.85	6.75	7.55	8.0	6.95	6.9
17	.....	7.7	6.7	7.85	7.45	6.9	6.9
18	.....	7.6	6.7	8.2	7.4	6.9	7.15
19	.....	7.3	6.75	8.8	7.4	7.1	7.0
20	... (1) ..	7.6	6.5	9.6	7.3	7.1	6.9
21	8.02	7.65	6.7	9.6	7.3	7.1	6.9
22	8.03	7.0	7.1	9.75	7.3	7.1	6.9
23	8.04	7.8	7.55	9.65	7.3	7.2	6.9
24	8.56	7.65	6.8	9.6	7.25	7.2	6.9
25	8.02	6.75	7.15	9.45	7.15	7.1	6.9
26	8.06	7.35	7.5	8.95	7.0	7.0	6.9
27	8.06	7.45	6.4	9.0	6.95	7.0	6.9
28	8.05	7.6	7.35	8.55	6.9	6.9	6.9
29	8.03	6.7	6.55	8.55	7.15	6.8	7.0
30	8.08	7.25	7.45	8.2	7.1	6.8	7.0
31	.....	6.95	6.45	.....	7.05	.....	7.0

[1] Station established.

The following table of drainage areas of Menominee River at various points is compiled from Water-Supply and Irrigation Paper No. 83:

Menominee River drainage areas.

	Square miles.
Brule River above Iron River	170.0
Iron River above mouth	94.7
Brule River, including Iron River	264.7
Brule River above Paint River	305.0
Paint River at mouth	738.5
Brule River at junction with Michigamme River	1,044.0
Michigamme River at mouth	723.7
Menominee River at junction of Brule and Michigamme rivers	1,767.7

	Square miles.
Menominee River above junction with Pine River	1,833.0
Pine River	586.0
Menominee River, including Pine River	2,419.0
Menominee River above Sturgeon River	2,538.0
Sturgeon River at mouth	396.0
Menominee River, including Sturgeon River	2,934.0
Menominee River above junction with Pemebonwon River	2,993.0
Peme Bon Won River	163.0
Menominee River, including Pemebonwon River	3,156.0
Menominee River above junction with Pike River	3,274.0
Pike River	292.0
Menominee River, including Pike River	3,566.0
Menominee River above Little Cedar River	3,792.0
Little Cedar River	149.0
Menominee River, including Little Cedar River	3,941.0
Menominee River at mouth	4,113.0

Water Powers.

GENERAL CONDITIONS.

Principally because of the opening up of the many rich and valuable iron mines of this region, and the resulting extensive railroad building, the valley of Menominee River has had a rapid development. The following railroads at present have extensions in this territory: Chicago, Milwaukee and St. Paul; Chicago and Northwestern; Minneapolis, St. Paul and Sault Ste. Marie; and Wisconsin and Michigan. All of them cross the Menominee one or more times, and several are near enough to run short spurs to the important water-power sites. The developed water power is at present used for the most part in mining and for the operation of lumber, paper, and pulp mills.

Menominee River varies in width from 200 to 600 or 700 feet far up toward the headwaters. For the first 7 miles from the junction of the Brule and Michigamme there are no heavy rapids, but, in the language of the lumberman, there is "strong water" all the way and probably many good water-power sites.

BAD WATER RAPIDS.

The first notable rapids, known as the Bad Water rapids, occur 7 miles below the head of the river, in sec. 27, T. 40 N., R. 19 E., at a point where the river, 100 feet wide, descends 5 feet over a ledge of rock. While definite information is lacking, it is likely that a dam could be built here, giving a head of 10 feet.

TWIN FALLS.

About 3½ miles below Bad Water rapids, in sec. 2, T. 39 N., R. 19 E., are the Twin Falls, about one-half mile apart. The vertical fall in each case is 12 feet, but the adjacent rapids are sufficient to increase the total descent to 28 feet.

PINE RIVER RAPIDS.

For 6 miles below the foot of Twin Falls the total descent of the river is but 20 feet, and the only rapids worthy of note are those extending for about five-eights of a mile on both sides of the mouth of Pine River. Here an island divides the river into two channels with rocky bed. The descent of the rapids at this point is said to be 6 feet, but as the banks are high a dam could develop more than this. Pine River increases the drainage area by 586 square miles.

HORSE RACE RAPIDS.

The most important rapids between Twin Falls and Big Quinnesec Falls, called the Horse Race, are found in sec. 7, T. 38 N., R. 20 E., both above and below the Chicago, Milwaukee and St. Paul railroad bridge. These rapids consist of two pitches, the upper of about 20 and the lower of 8 feet descent, separated by about 2,000 feet of less swift water. As the banks are high and the river narrow, it seems likely that a dam could be economically constructed here to develop about 40 feet of head. This site is only 3 miles from Iron Mountain, Mich. A view of the lower end of these rapids is shown in Fig. 1, Plate VII.

BIG QUINNESEC FALLS.

A little over 7 miles below the mouth of Pine River, and 4 miles from Quinnesec, are the Big (Upper) Quinnesec Falls. These are located in sec. 6, T. 38 N., R. 20 E. A view of these falls is shown in Fig. 2, Plate VII.

At Upper Quinnesec Falls the river narrows to hardly more than 50 feet wide (map measurement) between rocky banks of igneous origin. Immediately at the foot of the falls the river widens out, and about 800 feet below is 700 feet across. On the Wisconsin side

Fig. 2. THE HORSE RACE. MENOMINEE RIVER.

Fig. 2. UPPER QUINNESEC FALLS, NEAR IRON MT., MICH.
Menominee River. 54 feet head improved.

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LOWER QUINNESEC FALLS. MENOMINEE RIVER.
62 feet head improved.

the banks are 80 to 100 feet high and on the Michigan side 30 to 40 feet.[1]

Below the falls the river descends only 2 feet to the mile for a distance of about 3 miles. At present only 54 feet of the total head is improved, one-half of the power being used to compress air for the supply of the Chapin Iron Mines at Iron Mountain, 3½ miles distant. The remaining portion is to be harnessed in 1905 and used for operating mines at Norway, 9 miles away. On acount of the local conditions it is unlikely that much more than the present head can be economically developed.

LOWER OR LITTLE QUINNESEC FALLS.

Four miles below in sec. 10, T. 38 N., R. 20 E., are the Little (lower) Quinnesec Falls, which, together with the upper falls, described above, form the most important powers on the river. For the greater portion of the distance between the upper and lower Quinnesec Falls there is comparatively quiet water. The greater part of the descent of 24 feet in this distance occurs in the lower 2 miles. Above the upper and below the lower falls the banks are generally high near the the river, but between these falls the hills recede from the river an average distance of about one-half mile and are separated from it by a flat and in some places swampy area. A view of the Falls is shown in Plate VIII.

Maj. T. B. Brooks, who reported on the geology of this district, considered that the shore deposits indicated the presence of a lake at a comparatively recent date.

Above Little Quinnesec Falls the river runs southwest, but at the foot of the falls it suddenly turns at right angles and runs southeast, the water surging down an incline of about 45° and then plunging into the comparatively still water of the basin below. The total fall is 62 feet. A short distance above the falls the river is 250 feet wide, but narrows down at the pitch to about 50 feet. The falls are hemmed in by great masses of greenstone and schist rock. Along the Michigan side a steep cliff of greenstone at least 140 feet high forms the bank for a distance of a mile or more. A smaller, but similar, rib of rock forms the Wisconsin bank for about 700 feet.

Formerly Little Quinnesec Falls were partially developed under 25 feet head for woodpulp grinding; but in 1898 they were redeveloped

[1] Tenth Census, vol. 17.

by the Kimberly & Clark Company for wood-pulp and paper manufacturing. A ledge of rock, which is used for a bridge pier, divides the falls into two channels. The present development gives a net head of 62 feet, equivalent to 8,370 theoretical horsepower. An actual installation of turbines, generating 5,800 horsepower, consumes all the available power.

SAND PORTAGE RAPIDS.

These rapids lie between Little Quinnesec Falls and the mouth of Sturgeon River. They receive this name because the Indians, in making their "carry" around part of them, passed over a large amount of sand. The rapids are scattered along a distance of 6 miles, in which space there is a descent of 60 feet. About half of this amount is concentrated in the 1½ miles between the falls and the old cable bridge or ferry below. As the topographic map shows very high banks, fairly close together, a head of 25 feet or more may some day be developed here. The Chicago and Northwestern Railway is distant only 1.5 miles.

Between the above-described dam site and a point 2.5 miles below, the river descends 27 feet. A point due south of Norway, Mich., and on the road leading from that city is probably the best location for the dam to develop this fall, but even here a dam not less than 700 feet long would probably be required.

Menominee River descends but 6 feet between this point and the mouth of Sturgeon River. This may be considered a part of the Sturgeon Falls power.

STURGEON FALLS.

From below the mouth of Sturgeon River to a point just above Pemebonwon River, a distance of 10 miles, the drainage area increases from 2,934 square miles to 2,993 square miles. In this stretch are Sturgeon Falls, one-half mile below the mouth of Sturgeon River, in sec. 22, T. 38 N., R. 21 E., Wisconsin. These falls have high rock-ledge banks, with two pitches aggregating 13 feet. By backing the water a distance of about 3 miles this head could be increased to 15 feet. At the head of the falls the river narrows to about 200 feet, but at the foot it spreads out into a broad basin. In order to use the power it will probably be necessary to blast out a race in the rocks or build a flume and locate the mill at or near the foot of the rapids.

In the next 10 miles the river descends only 17 feet, with a fairly even grade, except for two or three small rapids. The largest of these, Nose Peak rapids, is about 1,000 feet long and descends about 4 feet.

PEMENA DAM AND RAPIDS.

A logging dam which, together with the adjacent rapids, gives a fall of 14 feet in a distance of a quarter of a mile, is located in sec. 24, T. 37 N., R. 21 E. The Minneapolis, St. Paul and Sault Ste. Marie Railway crosses the river 2½ miles above the dam and passes within a fraction of a mile from it. The operation of a dam at this point for lumbering purposes greatly lessens the amount of available power. At the present rate of progress, however, this dam will be needed for logging only a few more years. It has been found elsewhere in the State that river logging, except for pine, can not compete with railroad transportation.

From below Pemebonwon River to a point just below Pike River, a distance of 18 miles, the drainage area increases from 3,156 square miles to 3,566 square miles. Pemena, Chalk Hill, and White rapids occur in this distance.

About a mile above the mouth of Pemebonwon River, in sec. 8, T. 36 N., R. 21 E., the Pemena rapids begin. They extend for a distance of about 2 miles, with a total descent of 20.2 feet.[1] The river bed here is a metamorphic slaty schist, and the location is said to be favorable for a dam site. The Wisconsin and Michigan Railway runs parallel to the river at this point and is only 2 miles distant, and the Minneapolis, St. Paul and Sault Ste. Marie Railway crosses the river a few miles above.

CHALK HILL RAPIDS.

In the 11 miles between the foot of Pemena rapids and the head of White rapids the river descends 38 feet, the grade being even except for three small rapids of from 3 to 6 feet each. Chalk Hill rapids, the most important of these three, are located in sec. 6, T. 35 N., R. 21 E. They run over a slaty rock at a point said to be suitable for a dam, and if developed in connection with other falls about half a mile above would give a total head of 8 feet or more.

[1] This statement is based on an accurate profile of the river, prepared by Mr. T. W. Orbison, C. E. from his actual surveys. The statement made in the Tenth Census, vol. 17, p. 61, that the total fall is 70 feet, is evidently an error.

WHITE RAPIDS.

Four miles above the mouth of Pike River, in sec. 19, T. 35 N., R. 21 E., are the White rapids. The bed of the river is said to be gravel and bowlders, and the banks are high enough to give a head of 30 feet, thus developing the fall for 3 miles. Even above this limit the river descends 10 feet in 1¼ miles, as will be seen from the profile (p. 51). A head of 30 feet at ordinary low water would develop 5,350 theoretical horsepower.

From below Pike River to a point just above Little Cedar River, a distance of 25 miles, the drainage area increases from 3,566 to 3,792 square miles.

All the rapids thus far described have been over the pre-Cambrian crystalline rocks. In the next 28 miles the river crosses the Cambrian sandstone and "Lower Magnesian" limestone. No falls or rapids worthy of note occur until Grand rapids are reached, immediately above the mouth of Little Cedar River, in sec. 5, T. 33 N., R. 22 E. These rapids are caused by a descent over hard "Trenton" limestone, underlain by softer strata. They have a fall stated at 25 feet in a length of 3 miles, but of this fall only that in the lower 2 miles, amounting to 18 feet, can be cheaply developed. Both the Wisconsin and Michigan and the Chicago, Milwaukee and St. Paul railways pass within 2 or 3 miles of that site.

From below the mouth of Little Cedar River to the mouth of the Menominee, 23 miles, the drainage increases from 3,941 to 4,113 square miles.

TWIN ISLAND RAPIDS.

These rapids are situated about 7 miles below the Grand rapids and 16 miles from the mouth of the river. They extend for three-fourths of a mile and are said to descend 10 feet. The two islands lie one below the other, dividing the river into east and west channels. The bed of the river is limestone, the banks are steep, and a dam could be built across each channel to the islands. The total length of such dams is estimated at about 700 feet. A sawmill with a 6-foot head once occupied the east channel.

SCHAPPIES RAPIDS.

Located about 5 miles from the mouth of Menominee River, in T. 31 N. and between Rs. 22 and 23 E., Schappies rapids extend for a

distance of about a mile. During the winter of 1897 a survey was made of these rapids by a competent engineer, Mr. C. B. Pride, at a time of extreme low water. He found a discharge of 2,370 second-feet and determined that a head of 18 feet could be economically obtained. This power belongs to the Menominee River Boom Company. The Chicago, Milwaukee and St. Paul Railway is located about 3 miles distant.

MARINETTE DAMS.

The last series of rapids is found at Marinette, Wis., near the mouth of the Menominee. The natural channel probably had about 12 feet descent here, but the Menominee River Boom Company built three dams, one above another, the upper one backing the water to the foot of Schappies rapids. The first of these dams, 850 feet long, located about 3 miles from the mouth of the river, in T. 30 N. and near the line between Rs. 23 and 24 E., develops a head of 7 feet.[1] Power is applied to two paper and pulp mills owned by the Marinette and Menominee Paper Company and also to a flouring mill. No statement of the turbine installation at the paper mills is made, but that at the flouring mill is 95 horsepower.

The third dam from the mouth is located on the west line of sec. 1, T. 30 N., R. 23 E. This dam is 940 feet long and has a head of 18 feet. The middle or second dam is located about a quarter of a mile below the third dam and is 700 feet long, with a head of 7 feet. It is used for boom purposes only. The Marinette and Menominee Paper Company mill is located just below this dam, but it takes power through a canal from the third dam. Its turbines therefore work under a total head of about 24 feet.

The owners of these three dams state that each could be raised from 5 to 10 feet higher than at present.

TRIBUTARIES OF MENOMINEE RIVER.

The notable Wisconsin tributaries of Menominee River are Brule, Pine, Pemebonwon, and Pike rivers.

Brule River courses in a bed composed mostly of gravel and bowlders of the drift, and for this reason has few vertical falls, one of 10 feet being said to exist at its mouth. It is described as having a series of rapids or "strong water" for its entire length of 42 miles. Its

[1] Data regarding the Marinette dams furnished by the owners.

total drainage area, including that of Paint River, is 1,044 square miles.

The following table gives a fairly complete profile of Brule River:

Profile of Brule River, Wisconsin, from its mouth to sec. 23, T. 41 N., R. 14 E.[1]

No.	Station.	Distance.		Elevation above sea level.	Distance between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Brule, Wis. (C. &. N. W. bridge)	7.0	.....	1,260	.....	.....
2	½ mile below section line 22-23, T. 41 N., R. 15 E.	24.0	‡17.0	1,411	151	8.8
3	Center of bend E. ¼ stake, sec. 31, T. 41 N., R. 15 E.	29.5	5.4	1,431	20	3.7
4	¼ mile west of east line, sec. 24, T. 41 N., R. 14 E.	31.6	2.1	1,468	37	18.0
5	0.4 mile below dam. Noted below	33.1	1.5	1,490	22	14.6
6	Above dam 800 feet east of ¼ post, sec. 22-23, T. 41 N.. R. 14 E	33.5	.4	1,507	17	42.5
7	¼ mile last of section line, 22-23, T. 41 N., R. 14 E.	35.5	2.0	1,520	13	6.5

[1] Authority: No. 1, Chicago and Northwestern Railway; Nos. 2-7, U. S. Geol. Survey.

Pine River, the largest tributary lying wholly in Wisconsin, has a total length of 53 miles and drains an area of 586 square miles.

In the first half mile from its mouth the current is very rapid[2]; in the next 12 or 13 miles the fall is comparatively slight, and in the next three miles there are two falls of 8 feet each 1,000 feet apart, half a mile of strong water, succeded by another fall of 12 feet, then, half a mile above, a fall of 40 feet. Sixty feet above this is a logging dam belonging to the Menominee River Improvement Company.[2]

The length of Pike River is 48 miles.

[2] Tenth Census.

Dams on Menominee River and Tributaries.

The location and height of dams on Menominee River and tributaries in Wisconsin are shown in the following table:

Dams on Menominee River and tributaries in Wisconsin.[1]

Dam.	Section.	Township.	Range.	Height of dam.
Menominee river:				*Feet.*
Menominee River:				
1	6	30	24	7
2	1	30	23	7
3	33	31	22	14
Pemena dam	24	37	21	12
Pike River:				
1	8	35	21	9
2	16	35	20	13
North Branch of North Branch Pike River	28	37	18	13
North Branch Pike River:				
1	32	36	20	9
2	20	36	20	13
South Branch Pike River:				
1	19	35	20	13
2	31	36	19	9
3	35	36	18	11
4	29	36	18	10
5	17	36	18	6
Pine River:				
1	30	39	18	9
2	11	39	15	10
3	10	39	14	10
4	36	40	13	9
Brule River:				
1	5	40	17	7
2	19	41	16	8
3	15	42	13	8
Wheeler dam	23	41	14	10

[1] Information furnished by the owners.

PESHTIGO RIVER.

Drainage and Geology.—The drainage area of Peshtigo River includes 1,123 square miles, with an extreme length of 80 miles and average width of only 14 miles. The upper two-thirds of its length is in the pre-Cambrian region while in the lower third it crosses successively the Potsdam sandstone and the lower magnesian and Trenton limestones. The most important falls and rapids are all in the pre-Cambrian region. Because of the narrow water shed the Peshtigo tributaries are of small extent.

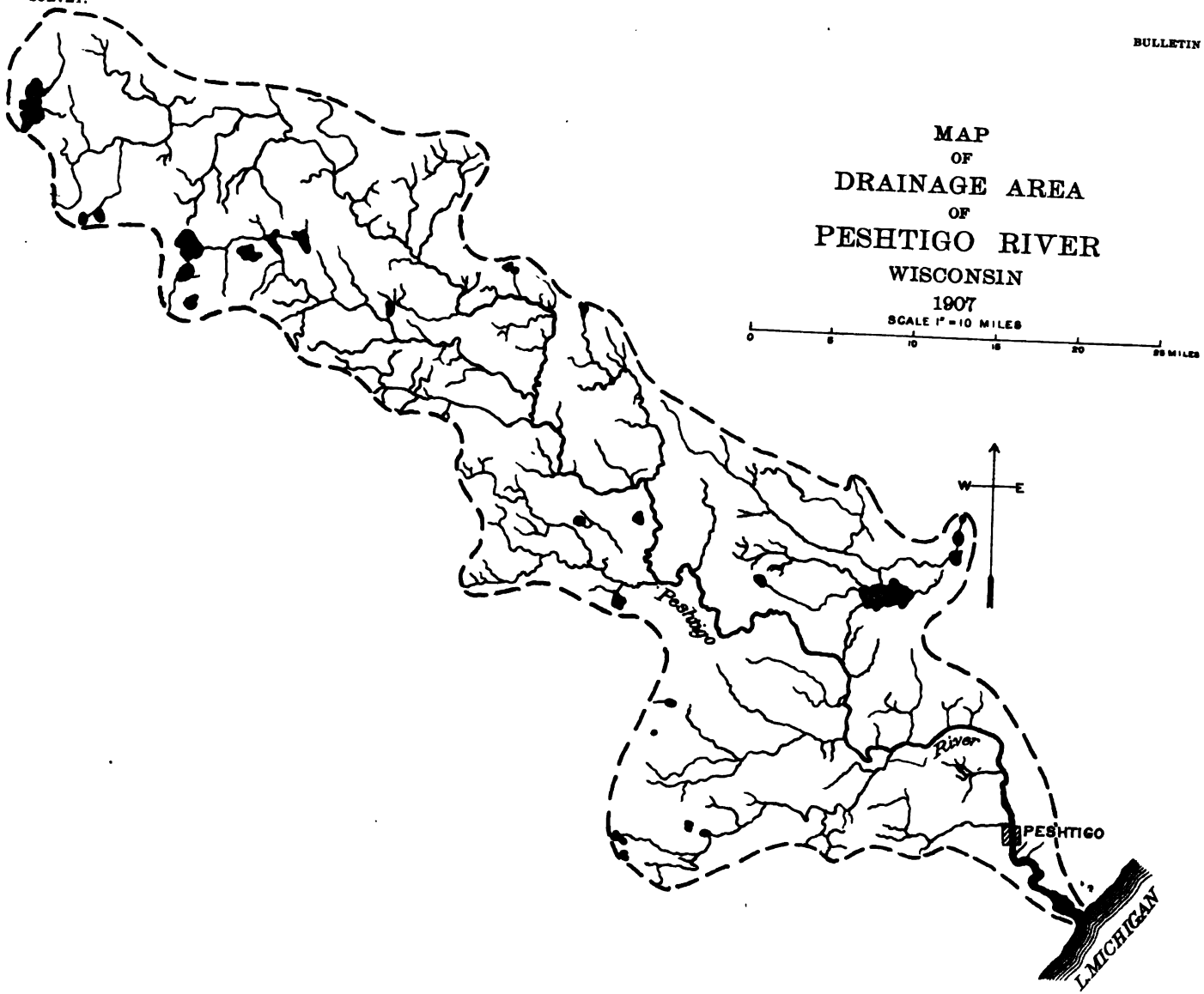
Fall of the River.—Peshtigo River rises in the highest land of northern Wisconsin. At Crandon the river has an elevation of 1,620 feet above the sea. In a length of about 94 miles it descends 1,040 feet, emptying into Lake Michigan about 7 miles south of Marinette. This average gradient of 11 feet per mile gives rise to more and lerger rapids than any other river in Wisconsin. This fact together with the usual high and rocky banks insures numerous water powers. The relatively small drainage area is more than offset by the size of the rapids.

PESHTIGO RIVER SURVEY.

In order to point out the power possibilities along Peshtigo River, a survey was made during 1906 from the city of Peshtigo to Sec. 10, T. 35, R. 17 E. From the data collected on this survey sheets have been prepared showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features.

The results of this survey have been published on separate sheets and may be had upon application to the Director of the Geological Survey.

The following table gives the profile of the river with great detail including the fall of every rapids in the part surveyed.


MAP
OF
DRAINAGE AREA
OF
PESHTIGO RIVER
WISCONSIN
1907
SCALE 1" = 10 MILES
0
5
10
15
20
25 MILES
W
E
Peshtigo
River
PESHTIGO
L. MICHIGAN

CALIFORNIA

Profile of Peshtigo River.

No.	Station.	Distance		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	0	.....	581.2	.....	.....
2	Peshtigo C. & N. W. Ry. crossing	12±	12	590.4	9.2	0.76
3	Peshtigo Dam, foot of	12.5	.5	593	2.6	5.2
4	Peshtigo Dam, crest of	12.5	.....	601.5	85.0	.....
5	S. Line, Sec. 34, T. 31 N., R. 22 E.	17.6	5.1	603	1.5	0.3
6	Foot of Potato Rapids	19	1.4	609	6	4.3
7	Head of Potato Rapids	19.6	.6	619	10	16.9
8	Hastings Rapids, foot of	31	11.4	631	12	1
9	Hastings Rapids, head of	31.7	.7	636	5	7
10	Crivitz Dam, foot of	46.2	14.5	661	25	1.7
11	Crivitz Dam, head of	.....	.....	679.5	18	.....
12	Lower Sandstone Rapids, foot of	50.5	4.3	680.5	1.5	.3
13	Lower Sandstone Rapids, head of	50.8	.3	698	17.5	58.3
14	Upper Sandstone Rapids, foot of	50.85	.05	700	2	5.7
15	Upper Sandstone Rapids, head of	50.95	.1	706.5	6.5	65
16	Seymour Rapids, foot of	56.9	5.95	745	38.5	6.4
17	Seymour Rapids, head of	57.25	.35	763	18	51.5
18	Johnson Falls, foot of	60.05	2.8	770	7	2.5
19	Johnson Falls, head of	60.75	.7	800	30	42.9
20	High Falls, foot of	63.85	3.1	815	15	5
21	High Falls, head of	64.55	.7	850	35	50
22	Twin Falls, foot of	67	2.45	865	15	6
23	Twin Falls, head of	67.3	.3	875	10	33.3
24	Mouth of Little Eagle River	72.3	5.0	896	21	4.2
25	Caldron Falls, foot of	72.8	.5	897	1	2
26	Caldron Falls, head of	72.96	.16	951.5	54.5	340
27	Breakwater Rapids, foot of	77	4.04	957.5	6	1.5
28	Breakwater Rapids, head of	77.05	.05	961.5	4	80
29	Roaring Rapids, foot of	80	2.95	986	24.5	8.2
30	Roaring Rapids, head of	82.8	2.8	1135	149	53.2
31	Farm Dam, foot of	83.5	.7	1147	12	17.1
32	Farm Dam, head of	.....	.....	1153.5	6.5	.....
33	Wilson Rapids, foot of	86.4	3.9	1154	.5	.15
34	Wilson Rapids, head of	86.45	.05	1161	7	140
35	Skinner Rapids, foot of	89	2.55	1165	4	1.6
36	Camp Seven Rapids, head of	90	1	1184.5	19.5	19.5
37	Taylor Rapids, foot of	93	3	1190	5.5	1.8
38	Taylor Falls, head of	93.7	.7	1227	37	52.9
39	North Crandon R. R. Crossing	140±	46.3	1620	393	8.4

PESHTIGO RIVER AT CRIVITZ, WIS.

This station was established April 20 and was discontinued December 12, 1906. It was located on the railroad bridge about one-fourth mile south of Crivitz post-office (or Ellis Junction railroad station).

The channel is straight for about 1,000 feet above and 300 feet below the station. Both banks are of medium height and do not overflow; all the water passes the section, being confined by the railroad embankments. The bed of the stream is gravel and is permanent. There is but one channel at all stages. The current is medium. Log jams and sunken logs affect the discharge at times.

Discharge measurements are made from the upstream side of the bridge, to which the gage is attached.

A standard chain gage, attached to the upstream side of the bridge, was read during 1906 by Andrew Johnson; length of chain, 22.85 feet. The bench mark is the top of parapet wall of left abutment, extreme downstream end, near front face, marked with white paint; elevation, 21.52 feet. The reference point is the center of gage pulley; elevation, 22.66 feet. Elevations refer to the datum of the gage.

Discharge measurements of Peshtigo River at Crivitz, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq ft.*	*Feet.*	*Sec.-ft.*
April 20	Horton and Brennan	136	897	9.88	2,520
June 8	M. S. Brennan	135	822	9.70	2,030
June 29	do	127	650	8.26	1,560

Daily gage height, in feet, of Peshtigo River at Crivitz, Wis., for 1906.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.9	7.9	6.2	4.3	5.7	5.7	6.7	6.9
2	.....	8.4	6.8	6.0	5.6	6.1	5.4	6.3	7.0
3	.....	9.5	6.7	6.1	5.0	5.5	5.2	6.7	7.4
4	.....	7.2	6.4	6.0	4.3	6.6	4.0	6.2	6.5
5	.....	7.9	6.7	8.5	5.3	6.6	5.4	5.7	6.2
6	.....	8.4	7.9	7.1	5.8	6.2	5.3	5.9	6.3
7	.....	6.6	8.5	6.8	5.8	6.2	5.4	5.9	6.5
8	.....	7.3	8.4	6.6	6.1	5.6	5.4	5.9	6.2
9	.....	8.2	9.7	6.8	5.9	5.6	5.2	5.8	6.0
10	.....	6.4	9.8	6.5	5.8	4.0	5.7	5.7	6.1
11	.....	7.1	7.4	6.1	5.7	5.5	5.3	5.9	5.8
12	.....	5.9	6.9	6.6	5.9	5.8	5.4	6.0	6.2
13	.....	6.7	7.7	6.2	5.5	5.7	5.6	5.9	.....
14	.....	6.5	7.3	6.0	6.4	5.7	5.4	6.0	.....
15	.....	7.7	8.4	6.6	5.0	5.4	5.6	6.0	.....
16	.....	6.5	8.3	6.5	5.5	5.5	5.3	5.9	.....
17	.....	6.5	6.2	6.8	5.2	5.8	5.4	5.9	.....
18	.....	6.0	6.1	6.4	5.3	5.9	5.3	6.1	.....
19	.....	6.7	6.3	6.5	5.3	6.5	5.4	5.7	.....
20	9.8	6.2	7.5	6.1	5.6	6.0	5.6	5.7	.....
21	10.4	6.5	7.5	6.6	5.3	5.8	6.6	5.8	.....
22	10.7	6.7	8.5	6.5	5.7	5.8	6.5	6.0	.....
23	10.6	6.6	8.4	5.8	5.6	5.7	6.6	5.9	.....
24	10.5	6.5	8.5	5.3	5.4	5.7	6.7	5.8	.....
25	9.9	7.1	8.5	5.4	6.2	5.9	6.8	5.8	.....
26	9.3	6.6	.....	5.7	5.2	5.7	6.9	7.0	.....
27	8.5	8.4	.....	5.7	6.1	5.9	7.5	6.8	.....
28	8.6	8.7	.....	5.7	6.0	6.4	7.3	7.2	.....
29	8.5	7.4	6.9	5.8	6.8	6.0	7.2	6.8	.....
30	8.1	7.7	7.0	5.6	6.1	5.7	6.8	6.9	.....
31	.....	7.9	.....	5.3	6.0	.....	6.7	.....	.....

PESHTIGO RIVER AT HERMAN'S FARM, NEAR CRIVITZ, WIS.

This station was established September 7, 1906, under the direction of D. W. Mead. It is located on Herman's farm, 4½ miles west of Crivitz, Wis., in the northwest quarter of sec. 26, T. 32 N., R. 19 E.

The channel is straight for about 800 feet above the station and for 300 feet below. The banks do not overflow. The bottom of the river is gravel and permanent, with one channel at all stages. The current is swift.

Discharge measurements are made from a boat which is held in position by means of a rope stretched across the river.

The gage, which is read daily by Rose Herman, consists of two sections. The bench mark is a copper nail in top of a pine stump 50 feet from the water's edge and about 50 feet southeast of the gage; elevation, 731.70 feet above sea level and 19.82 feet above the datum of the gage.

Discharge measurements of Peshtigo River at Herman's farm, near Crivitz, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
September 7	V. H. Reineking	128	436	3.40	657
October 27	do	130	463	4.20	1,020
November 16	do	125	380	3.20	562

Daily gage height, in feet, of Peshtigo River at Herman's farm near Crivitz, Wis., for 1906.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1		3.0	3.7	4.2	17	3.4	3.0	3.4	3.3
2		2.95	3.75	4.0	18	3.45	3.05	3.5	3.3
3		3.3	3.5	3.9	19	3.5	3.3	3.5	3.35
4		3.25	3.4	3.9	20	3.4	3.5	3.45	3.4
5		3.0	3.4	3.8	21	3.4	3.7	3.5	3.3
6		3.0	3.35	3.6	22	3.4	3.8	3.3	3.2
7	3.4	2.95	3.35	3.6	23	3.45	3.8	3.3	3.25
8	3.2	3.0	3.4	3.5	24	3.4	3.9	3.35	3.15
9	3.0	3.0	3.4	3.6	25	3.4	4.0	3.4	3.1
10	3.0	3.05	3.5	3.55	26	3.4	4.1	3.8	3.1
11	3.0	2.8	3.5	3.5	27	3.0	4.2	4.0	3.05
12	3.15	3.2	3.45	3.3	28	3.7	4.15	4.2	3.15
13	3.2	3.05	3.4	3.35	29	3.35	4.2	4.3	3.1
14	3.1	3.0	3.3	3.3	30	3.15	4.0	4.25	3.05
15	3.1	3.0	3.25	3.3	31		3.9		3.1
16	3.3	3.0	3.2	3.3					

Daily gage height of Peshtigo River at Herman's Farm, Crivitz, Wisconsin for 1907.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	3.30	2.90	4.60	4.70	3.80	3.85	2.70	2.50	2.95	2.60	2.55
2	3.10	3.15	2.90	4.65	4.60	3.70	3.95	2.65	2.50	2.95	2.60	2.55
3	3.10	3.20	2.95	4.50	4.60	3.80	3.70	2.60	2.40	2.90	2.60	2.50
4	3.10	3.30	3.00	4.55	4.80	3.70	3.00	2.60	2.50	2.90	2.60	2.50
5	3.20	3.30	2.95	4.50	4.80	2.70	3.25	2.65	2.50	2.90	2.60	2.50
6	3.10	3.45	3.00	4.35	4.90	3.00	3.75	2.65	2.55	2.80	2.60	2.50
7	3.10	3.45	3.00	4.35	5.00	3.20	3.00	2.65	2.60	2.80	2.55	2.60
8	3.05	3.25	2.90	4.20	5.10	3.50	3.65	2.65	2.70	2.75	2.55	2.50
9	2.75	3.20	2.95	4.20	5.15	3.35	2.80	2.60	2.80	2.70	2.55	2.60
10	3.20	3.05	3.00	4.00	4.10	4.25	3.15	2.60	2.80	2.70	2.50	2.60
11	3.20	3.10	3.00	4.00	5.20	3.90	2.50	2.60	2.90	2.70	2.50	2.55
12	3.25	3.05	2.90	4.00	4.40	3.75	2.45	2.70	3.00	2.70	2.45	2.50
13	3.30	3.05	2.80	3.95	4.30	4.45	2.30	2.65	3.10	2.70	2.60	2.45
14	3.20	3.10	2.80	2.70	4.00	4.00	2.30	2.60	3.05	2.70	2.25	2.40
15	3.25	3.10	2.75	3.80	5.55	4.00	2.20	2.55	3.00	2.75	2.25	2.50
16	3.30	3.15	2.85	3.50	5.70	2.90	2.30	2.55	2.95	2.80	2.25	2.50
17	3.30	3.10	2.80	2.70	5.80	3.25	2.90	2.50	2.95	2.75	2.60	2.50
18	3.00	3.05	2.75	2.80	5.75	2.50	2.85	2.50	2.95	2.75	2.55	2.50
19	3.00	3.05	3.00	2.80	5.60	2.90	2.85	2.55	3.65	2.70	2.55	2.50
20	2.95	3.10	2.85	2.80	5.30	3.95	2.80	2.60	3.85	2.70	2.50	2.55
21	3.10	3.00	3.00	2.80	4.90	4.00	2.75	2.65	4.00	2.65	2.60	2.45
22	3.00	3.00	3.05	2.85	5.10	3.50	2.70	2.70	3.95	2.60	2.65	2.55
23	3.00	2.90	3.30	2.90	5.00	3.05	2.70	2.70	3.80	2.60	2.65	2.50
24	3.10	2.90	3.50	3.00	4.65	3.00	2.70	2.70	3.65	2.60	2.60	2.45
25	3.15	2.90	3.70	3.00	4.85	2.75	2.70	2.70	3.55	2.85	2.60	2.45
26	3.15	2.90	3.95	3.00	4.55	2.75	2.80	2.65	3.35	2.75	2.60	2.45
27	3.20	3.00	3.90	3.00	4.30	2.70	2.70	2.60	3.20	2.65	2.60	2.45
28	3.25	2.90	4.40	3.20	4.25	3.00	2.70	2.60	3.05	2.60	2.60	2.50
29	3.30		4.65	4.40	4.20	2.60	2.70	2.60	3.00	2.60	2.55	
30	3.30		4.80	4.70	4.05	2.60	2.60	2.55	2.95	2.60	2.56	
31	3.25		4.65		4.00		2.60	2.55		2.60		

Rating table for Peshtigo River at Herman's farm, near Crivitz, Wis., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
2.30	280	2.90	455	3.40	645	3.90	870
2.40	305	3.00	490	3.50	690	4.00	920
2.50	330	3.10	525	3.60	735	4.10	970
2.60	360	3.20	565	3.70	780	4.20	1.020
2.70	390	3.30	605	3.80	825	4.30	1,070
2.80	420						

NOTE.—The above table is applicable only for open-channel conditions. It is based on three discharge measurements made during 1906, and is well defined between gage heights 3.2 feet and 4.2 feet.

Monthly discharge of Peshtigo River at Herman's farm, near Crivitz, Wis., 1906.

Months.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
September (7-30)	780	490	601
October	1,020	280	646
November	1,070	565	710
December	1,020	508	653

NOTE.—Values for 1906 are good.

WATER POWERS.

The following report is based on an accurate survey of the river extending from the Peshtigo to the head of Taylor's Rapids in Section 10, Township 35, Range 17 E., a distance of 81.7 miles. For this entire distance, accurate spirit levels were run, and the adjacent topography was taken by the transit and stadia during the fall of 1906 The elevation of the center of the Chicago and Northwestern Railway bridge over Peshtigo River at Peshtigo, as given by the chief engineer of that road, was accepted and used as the datum of the entire survey.[1]

Below Peshtigo the river has a very meandering course, the last few miles being in a marsh. The entire fall in this stretch of 12 miles is only 9.2 feet.

Peshtigo Dam.—The first opportunity for a dam is at Peshtigo just above the Wisconsin and Michigan railroad bridge, where the Peshtigo Lumber Company have installed a timber dam 200 feet long which has a head of 10 to 11 feet. The secretary of the company is H. J. Upham. This dam was first erected in 1839 and is in need of repair.

[1] D. H. Dugan was the chief of the field party on this work.

The company are now perfecting plans for a new masonry dam to replace present structure which shall have a crest of equal height but with provision for 10 inches of splash boards. The present turbine installation of 1,390 h. p. furnishes power for a saw mill but the company plans to greatly increase this installation soon. This company have 525 auxiliary steam power.

The Peshtigo Flour Mill Company, owned by A. Brietzkreuts, takes water power from this dam to the extent of 50 h. p.

Potato Rapids.—The Peshtigo dam backs the water nearly to Potato Rapids 6 miles above (by river). These rapids are located in Secs. 27 and 22, Township 31 North, Range 22 East, and include a fall of 10 feet in limestone within a distance of a mile. The banks are sand and clay and high enough to develop even a greater head than 10 feet. As the Wisconsin and Michigan Railroad parallels the left bank at this point, this power would have transportation facilities from the start while the proximity of the cities of Peshtigo and Marinette would seem to insure a ready market for the power.

Hasting's Rapids.—In the 11.4 miles between the head of Potato Rapids and the foot of Hasting's Rapids the river has a uniform fall of only one foot per mile. But in Section 30, Township 31 North, Range 21 East, are located Hasting's Rapids comprising a fall of 5 feet in about one-half a mile. The banks are sufficiently high in the N. E. ¼ of Section 31, Township 31 North, Range 21 East, to build a dam of 10 or more feet. Such a dam would be about 300 feet long and would back the water to some small rapids known as Anderson's about 5½ miles above this dam site.

By building an embankment on the left bank this dam site could probably be made to develop a head of 15 feet.

In the 14.5 miles betwen Hasting's Rapids and the Crivitz dam the river has a uniform fall of only 1.7 feet per mile.

Crivitz Dam.—This dam is located at Crivitz near the railroad station of Ellis Junction. The Crivitz Pulp and Paper Company have constructed here a timber dam 200 feet long with a wing dam 600 feet long on the right bank. The dam develops a head which varies between 18 and 20 feet and is in a good state of repair. The installation consists in 3 34-inch, 1 22-inch, 1 19-inch, and 1 pair of 27-inch turbines rated at about 800 h. p. under an 18 foot head. The topography is such as to prevent increasing the present head of this dam. The officers of the company are S. Duquaine, President; F.

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Fig. 1. JOHNSON'S FALLS. PESHTIGO RIVER.
(40 feet developable)

Fig. 2. HIGH FALLS. PESHTIGO RIVER.
(60 feet developable)

[illegible]

[illegible]

[illegible]

which occurs in a distance of only 400 feet, all located in the N. W. ¼ of Section 1, Township 32 North, Range 18 East. A view of these Falls is shown in Fig. 2, Plate X. A charter for a dam at this location was granted to Hieronymus Zech by chapter 261, laws of 1899, but no work of contsruction has yet been attempted. During the fall of 1906 the owners of Johnson and High Falls, F. H. Jossyln and associates, caused an accurate detail survey to be made of both rapids and the region between to determine the best way of developing these rapids.[1]

Several alternative plans for the development of this fall have been studied, and it has been shown that dams at Johnson and High Falls can be made to develop heads of 40 and 60 feet, respectively at a reasonable price.

As the drainage area above these rapids is approximately 576 square miles, an ordinary low water flow of about 600 cubic feet per second would be equivalent to 2,600 and 4,000 theoretical h. p., respectively.

The survey also shows that it is entirely feasible to build a 20 foot dam near the south line of Section 36, Township 33 North, Range 18 East, above both rapids, and by means of a canal about 2½ miles long, running eastward near the quarter line, of Sections 31 and 32 and south to a point opposite the foot of Johnson's Falls, deliver the water at a total head of 110 feet. The route of the canal would include a natural depression partly occupied by three lakes.

On the basis of a low water flow as given above, this fall should produce about 7,300 theoretical h. p.

This power would probably be conducted electrically to the cities of Menominee and Marinette.

Caldron Falls:—These falls have a total fall of 55 feet in a distance of about 800 feet, the largest single concentration of fall on the river. They are located in the NE. ¼ of Section 10, Township 33 North, Range 18 East. A small logging dam has been erected at the head of these rapids by the owners, the Peshtigo Lumber Company. The left bank is high but the right bank will allow the increasing of the present head only 20 feet. This would create a head of about 75 feet. The drainage area of the river above this dam site is approximately 440 square miles. The above improvement would cover up Breakwater Rapids in Section 6 and develop the fall

[1] This survey was under the charge of D. W. Mead.

Fig. 1. UPPER PART OF CALDRON FALLS, PESHTIGO RIVER.

Fig. 2. LOWER PART OF CALDRON FALLS, PESHTIGO RIVER.
Combined head 75 feet.

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to a point near the foot of Roaring Rapids. A view of Caldron Falls is shown in Plate XI.

Roaring Rapids.—These rapids extend continuously for a distance of 2.8 miles in which distance the river falls a total of 150 feet. A much more detailed survey will be required to determine the best way of developing this fall of 150 feet but it seems probable that two or even three dams will be required.

A good location which would develop the lower 50 feet would be near the east line of Section 36, Township 34 North, Range 18 East, at a point where the water has an elevation of 980 feet.

Farm Dam.—This logging dam is located in the SE. ¼ Section 22, Township 34 North, Range 17 East. As at present constructed is high enough to give a head of 12 feet but at the time of the survey the head was only 5 feet. The banks are in rock and rise on either side to a height of 40 feet above the present crest of the dam. To develop this increased head a dam about 700 feet long would be required but this would give a total head, including 10 feet just below the dam, of 60 feet. It would back the water to Taylor Rapids and would cover up Wilson Rapids, Skinner's Rapids, and Camp Seven Rapids. It would back the water up in Otter and Red Rivers and create a very large reservoir.

Wilson Rapids.—These rapids include a fall of 7 feet in 500 feet located 2.9 miles above Farm Dam in the NW. ¼ Section 11, Township 34 North, Range 17 East.

Skinner's and Camp Rapids.—These rapids which comprise falls of 6 and 72 feet, respectively, may be considered as one rapids, as they are separated by only 1,000 feet. They are located in the NE. ¼ of Section 35 and the SE. Section 26, Township 35 North, Range 17 East.

Taylor Rapids.—Including Strong Falls, Taylor Rapids includes a fall of 36 feet located in the NE. ¼ Section 15 and south half of Sec. 10, T. 35 N., R. 17 E. The Wisconsin and Michigan Railroad crosses the river at about the middle of the rapids. A dam could be built at the head of Strong Falls which would develop the entire fall of 36 feet and even more.

The Upper River.—No survey was made of the 46 miles between Taylor Rapids and North Crandon but the railroad elevation of the latter point shows that the river has a fall of 393 feet in this distance, or 8.4 feet per mile. While the gradient is much less than

in the 47 miles below Taylor Falls, it is still sufficient to insure many dam sites which must prove a valuable resource when the settlement of this region gives rise to a demand for power.

An approximate estimate of water powers on Peshtigo River.

No.	Location.	Appoximate estimated horse power.	Remarks.	Developable head.
		Theoretical.		
1	Peshtigo Dam	1,390	Turbines now installed.	10.5
2	Potato Rapids	1,400	Sec. 27 and 22, T. 31 N., R. 22 E. Clay banks.	11
3	Hastings Rapids	1,200	N. E ¼, sec. 31, T. 31 N., R. 21 E.	10
4	Crivitz Dam	3,800	800 h. p. of turbines installed.	18
5	Sandstone Rapids	2,800	The rapids include 24 feet.	40
6	Spring and Seymour Rapids	2,700	These rapids are 15 and 18 feet.	40
7	Johnsons Falls	2,500	Likely to be developed soon.	40
8	High Falls	3,700	Likely to be developed soon.	60
9	Caldron Falls	3.700	Likely to be devoloped soon.	75
10	Roaring Rapid.s	7,000	Located in sec. 36, T. 34 N., R. 18 E.	150
11	Farm Dam	2,500	Located in sec. 22 T. 34 N., R. 17 E.	60
12	Taylor Rapids	1.200	Located in sec. 10, T. 35 N., R. 17 E.	40
	Total	33,890		554.5

The above horse power has been computed on a low water run-off of 1 cu. ft. per second per sq. mile of drainage area.

The importance of the Peshtigo river as a power producer is emphasized by the above table, for it will be seen that its estimated horse power slightly exceeds the total turbine installation on the Lower Fox between Lake Winnebago and Green Bay.

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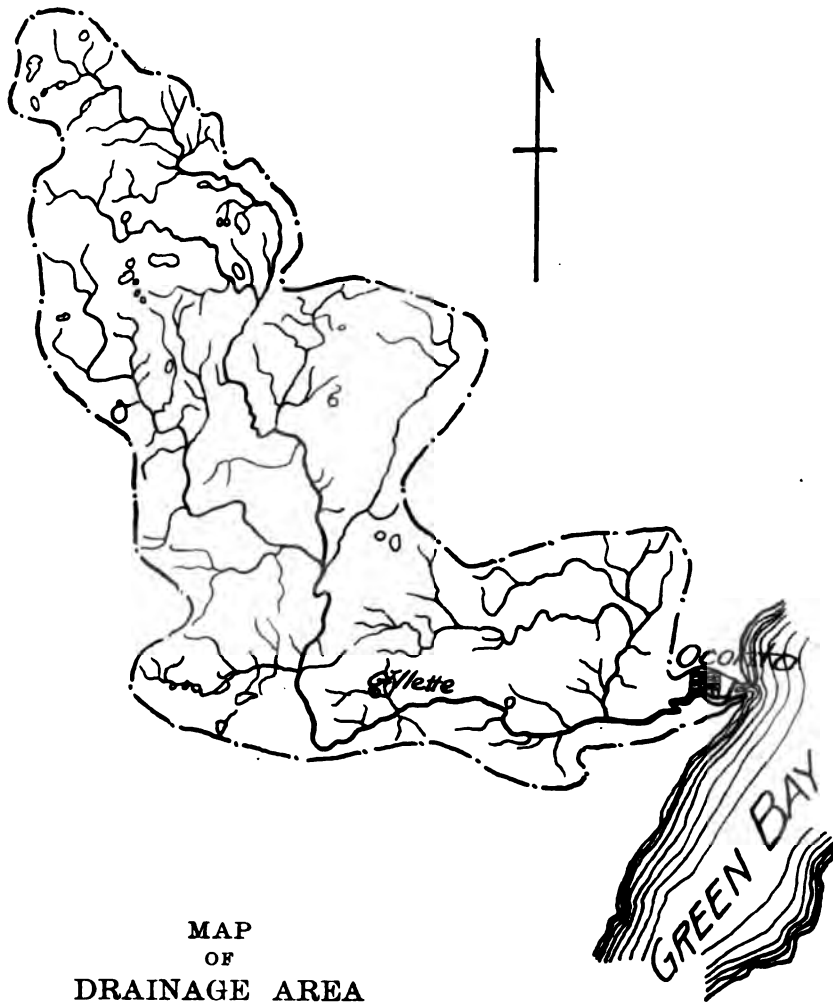

MAP
OF
DRAINAGE AREA
OF
OCONTO RIVER

Scale in miles

0 5 10 15

OCONTO RIVER.

General Conditions.

Oconto River rises in a number of small lakes and swamps in the plateau region, at an elevation of about 1,530 feet above the sea. In its length of 87 miles it descends 945 feet. In the upper 35 miles of its course the river flows over the crystalline rocks, and here is found about two-thirds of its total fall. Upon leaving the crystalline rocks the river flows nearly due south for 20 miles over the Cambrian sandstones. At Underhill it turns abruptly and flows nearly due east, crossing the "Lower Magnesian" and "Trenton" limestones and joining Lake Michigan near Oconto. The profile of the river is shown in the following table:

Profile of Oconto River, Wisconsin, from its mouth to Wabena.[1]

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Chicago & Northwestern Railway bridge, Oconto	2	.....	581	.....	.....
2	Chicago, Milwaukee and St. Paul Railway bridge, Oconto	7	5	590	9	1.8
3	Stiles	13	6	614	24	4.0
4	Underhill	33	20	770	156	7.8
5	Surings	44	11	791	21	1.9
6	One mile south of mountain	60	16	916	125	7.8
7	Two miles north of mountain	63	3	941	25	8.3
8	Wabena	87	24	1,526	585	24.3

[1] Authority: Nos. 1 and 4–8, Chicago and Northwestern Railway; Nos. 2 and 3, Chicago, Milwaukee and St. Paul Railway.

The most important powers are found in the last 33 miles of its course, in which distance the river descends 190 feet.

Water Powers.

STILES.

The first dam above the mouth of the Oconto River is located at Stiles, in sec. 34, T. 28 N., R. 20 E., where a dam 400 feet long, with 11-foot head, furnishes power for saw and pulp mills owned by the Anson Eldred Company. This company has installed turbines of 500 horsepower. It is reported that by constructing a dike about 450 feet long the head could be increased to 18 feet.

OCONTO FALLS.

The most important concentration of fall on the river, about 100 feet, occurs in the "Lower Magnesian" limestone at Oconto Falls, in Sec. 25, T. 28 N., R. 19 E. A dam owned by the Falls Manufacturing Company has a head of 37 feet and supplies power for a large paper and pulp mill. The company has installed turbines rated at 1,370 horsepower, besides 400 steam horsepower. About a quarter of a mile farther up is located a dam of 19-foot head, which furnishes power for a large pulp mill, belonging to the Union Manufacturing Company. Seven turbines rated at 940 horsepower are installed. These run twenty-four hours every day except Sunday. Only half a mile below the Falls Manufacturing Company's dam are some important rapids, where an excellent power is available. It is estimated that a dam 250 feet long would develop a head of nearly 40 feet. This power is owned by E. A. Edmonds, who has a charter for a dam at this point with a head of 27.5 feet. The Chicago and Northwestern railway furnishes excellent shipping facilities at all the Oconto Falls powers described above.

PULCIFER DAM.

The last dam used for power purposes is located in Sec. 6, T. 27 N., R. 18 E., and furnishes power for a gristmill. It is also used for logging purposes.

MISCELLANEOUS POWERS.

The following table gives the location and extent of the most important developed and undeveloped water powers on the Oconto River:

Water powers on Oconto River.

No.	Location.	Estimated head.a	H. P. installed.	Use.
	DEVELOPED POWERS.	*Feet.*		
1	Stiles, sec. 34, T. 38 N., R. 20 E	11	500	Saw and pulp mill.
2	Oconto Falls, sec. 25, T. 28 N., R. 19 E	37	1,370	Paper and pulp mill.
3	Oconto Falls, sec. 26, T. 28 N., R. 19 E	19	940	Pulp Mill.
4	Pulcifer, sec. 6, T. 27 N., R. 18 E	12	45	Flouring mill and driving
5	Sec. 25, T. 31 N., R. 16 E	12		Driving only.
6	Sec. 4, T. 31 N., R. 16 E	10		Do.
7	Sec. 23, T. 33 N., R. 16 E	10		Do.
8	Sec. 30, T. 33 N., R. 17 E	12		Do.
9	Sec. 5, T. 33 N., R. 16 E	10		Do.
10	Sec. 1, T. 33 N., R. 15 E	10		Do.
11	Sec. 11, T. 32 N., R. 16 E	10		Do.
12	Sec. 34, T. 33 N., R. 16 E	10		Do.
13	Sec. 30, T. 33 N., R. 16 E	10		Do.
14	Sec. 27, T. 33 N., R. 15 E	12		Do.
15	Sec. 18, T. 31 N., R. 17 E	10		Do.
16	Sec. 33, T. 32 N., R. 17 E	10		Do.
17	Sec. 21, T. 32 N., R. 17 E	10		Do.
18	Sec. 23, T. 30 N., R. 16 E	10		Do.
19	Sec. 16, T. 30 N., R. 16 E	6		Do.
	UNDEVELOPED POWERS.			
20	Oconto, sec. 23, T. 28 N., R. 21 E	12		
21	Oconto Falls, sec. 31, T. 28 N., R. 20 E	40		
22	Sec. 34, T. 28 N., R. 18 E	15		
23	Sec. 23, T. 31 N., R. 16 E	20		

a The first four heads are reported by owners; the remainder are estimated by Mr. W. A. Holt, of the Holt Lumber Co., Oconto.

No discharge measurements on this river were made until June, 1906, at the following described stations:

OCONTO RIVER AT GILLETT, WIS.

This station was established June 7, 1906. It is located at the highway bridge about 2½ miles south of Gillett, Wis.

The channel is straight for about 200 feet above and 300 feet below the station. Both banks are low but do not overflow. The bed of the stream is gravel and is permanent. The current is swift. Old pier foundations at both banks may affect the flow somewhat.

A standard chain gage, which was read during 1906 by Samuel Gilbertson and Hattie Gilbertson, is fastened to the lower side of the bridge; length of chain, 24.82 feet. The reference point is the top of downstream board guard rail 59 feet from the initial point; elevation, 17.75 feet above gage datum.

Discharge measurements of Oconto River at Gillett, Wis., in 1906 and 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1906.		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 7	M. S. Brennan	81	359	2 58	5.95	926
June 29	do	77	339	2.14	5.72	727
1907.						
April 10	A. H. Horton	72	354	2.66	6.1	[1]940
June 24	G. A. Gray	76	327	2.01	5.67	685
July 22	do	61	283	1.43	5.2	421
August 26	do	55	246	1.28	5.0	329
August 26	do	55	246	1.28	4.9	326
October 11	do	55	254	1.29	5.0	341
November 8	do	56	264	1.49	5.15	405
December 13	do	58	311	1.07	6.1	334

[1] These discharges checked by a second measurement.

December 13 measurement made under half frozen and half open conditions. Velocity obtained by floating ice.

Discharge measurements under ice of Oconto River at Gillett, Wis., for 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height. Water sur.	Discharge	Av. th. of ice.	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec	Feet.	Sec.-ft.		
1908.								
January 17	G. A. Gray	58	233	1.33	6.3	310	1.2	.15
February 10	do	70	243	1.37	6.5	333	1.6	.9
February 10	do	70	243	1.38	6.5	335	1.6	.9
March 9	do	70	246	1.65	6.75	411	1.9	.1

Record of thickness of ice at Gillett, winter 1907–8.

1908.		Feet.
Dec. 17.	River closed.	
Dec. 24.	Average thickness of ice	.6
Dec. 31.	Average thickness of ice	.7
Jan. 8.	Average thickness of ice	1.0
Jan. 14.	Average thickness of ice	1.0
Jan. 23.	Average thickness of ice	1.3
Feb. 1.	Average thickness of ice	1.3
Feb. 10.	Average thickness of ice	1.6
Feb. 29.	Average thickness of ice	1.8
Mar. 5.	Average thickness of ice	1.7
Mar. 11.	Average thickness of ice	1.8
Mar. 21.	Average thickness of ice	1.4
Mar. 25.	River opened.	

Daily gage height, in feet, of Oconto River at Gillett, Wis., for 1906.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.4	4.75	5.15	5.1	6.05	6.7
2	.....	5.5	4.7	5.15	5.4	6.0	6.7
3	.....	5.7	4.75	5.7	5.2	5.9	6.6
4	.....	6.15	4.75	5.7	5.2	5.8	6.15
5	.....	5.75	4.2	5.5	4.9	5.8	6.95
6	.....	6.0	4.25	5.6	5.1	5.85	5.6
7	5.95	6.0	4.85	5.6	5.4	5.7	6.1
8	6.0	5.8	4.9	5.0	5.4	5.8	7.25
9	6.15	5.75	4.8	5.2	5.1	5.8	7.5
10	6.1	5.6	5.1	5.25	5.2	5.7	7.85
11	5.95	5.6	5.4	5.3	5.0	4.6	8.3
12	5.9	5.6	5.7	5.25	5.3	5.7	9.1
13	6.2	5.5	5.3	5.2	6.15	5.4	7.8
14	6.15	5.1	5.3	5.65	4.3	5.7	7.4
15	5.6	5.2	5.3	4.9	5.35	5.5	7.35
16	5.65	5.2	5.4	6.15	5.3	5.5	6.8
17	5.6	5.8	5.3	5.8	5.3	5.95	7.7
18	5.6	5.0	4.8	5.8	5.3	5.9	8.1
19	5.0	4.95	4.5	5.9	5.8	6.2	9.0
20	5.4	5.0	5.2	6.0	6.0	6.2	9.1
21	5.7	5.0	5.2	6.0	6.1	6.35	... (1) ..
22	6.0	5.5	5.2	5.1	6.0	6.3	.....
23	6.0	5.0	5.9	5.3	6.2	6.25	.....
24	6.2	4.9	5.6	5.5	6.15	6.15	.....
25	5.85	4.85	5.8	5.5	5.9	5.7	.....
26	5.75	4.8	6.0	5.5	6.1	7.05	.....
27	5.65	4.75	6.3	5.5	6.4	7.3	.....
28	5.75	4.75	6.2	5.4	6.4	7.35	.....
29	5.75	4.4	6.1	5.05	6.7	7.3	.....
30	5.65	4.7	5.9	5.0	6.3	7.2	.....
31	.....	4.7	5.6	.....	6.1	.....	.....

[1] Frozen.

Mean daily gage height, in feet, of Oconto River at Gillett, Wis., for 1907.

Day.	Mch.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.1	6.3	7.3	6.65	5.05	4.9	5.8	6.0	5.0
2	.....	7.2	7.1	4.45	5.5	5.1	4.9	5.85	5.2	5.4
3	.....	6.1	6.5	4.1	5.6	5.25	4.8	5.8	5.0	5.1
4	.....	6.5	6.7	5.5	5.7	5.0	4.7	5.7	5.2	5.2
5	.....	6.75	6.5	5.0	5.2	4.9	4.5	5.7	5.2	6.1
6	.....	6.7	5.9	5.1	5.1	5.6	4.9	5.4	5.2	6.5
7	.....	6.55	6.35	4.8	5.1	5.5	4.8	5.65	5.2	5.8
8	.....	6.9	6.2	5.1	4.9	5.0	4.8	4.8	5.15	5.3
9	.....	6.8	7.3	4.5	5.3	4.5	5.0	5.3	5.2	5.2
10	.....	6.1	5.8	7.1	4.8	4.5	5.1	5.2	5.1	5.3
11	.....	6.6	7.2	5.0	4.65	4.6	5.5	5.0	5.15	5.7
12	.....	6.3	7.45	5.2	6.0	4.6	5.4	5.05	5.2	5.9
13	.....	6.0	5.7	6.1	7.0	4.3	5.5	5.5	5.1	6.3
14	.....	6.6	6.1	6.2	4.5	4.35	5.7	5.3	4.7	6.6
15	.....	6.1	7.4	6.4	5.9	4.4	5.6	5.15	4.7	7.2
16	.....	5.6	6.2	5.9	5.0	5.2	5.5	5.0	5.1	7.0
17	.....	5.85	7.5	5.7	5.0	4.3	5.4	5.3	5.2	7.15
18	.....	6.5	6.2	6.0	6.05	4.75	5.55	5.0	5.4	. (1) .
19	.....	6.25	7.1	5.9	5.0	4.65	5.2	5.2	5.4	.....
20	.....	6.25	7.4	5.1	5.3	4.6	6.35	5.3	5.9	.....
21	.....	6.1	6.75	6.2	5.45	4.7	6.5	5.3	5.4	.....
22	. (1) .	7.1	6.5	7.35	5.2	4.85	6.8	5.25	5.6	.....
23	6.9	6.1	7.0	6.25	5.2	4.3	6.8	4.95	5.6	.....
24	6.6	6.5	7.4	5.65	5.1	4.9	7.0	5.05	5.45	.....
25	7.5	5.45	5.9	5.5	5.0	4.6	6.15	5.15	5.4	.....
26	7.5	6.0	8.0	6.5	5.2	4.7	6.1	5.1	5.4	.....
27	7.5	6.3	5.45	7.3	5.2	4.8	5.9	5.2	5.4	.....
28	7.75	6.4	5.0	7.4	5.1	4.8	6.0	5.0	5.4	.....
29	7.35	7.5	4.8	4.6	5.0	5.0	6.0	5.2	5.3	.....
30	7.25	6.1	4.7	7.0	5.1	5.05	6.1	5.1	5.2	.....
31	7.1	6.3	4.8	.....	5.1	5.0	.....	5.15	.....	.....

Dec. 6, river full of ice.
[1] Frozen.

OCONTO RIVER AT STILES, WIS.

This station was established April 20, 1906, but was discontinued June 6, 1906, as the dam immediately above the station seriously modified the flow.

Dicharge measurements of Oconto River at Stiles, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
April 20	Horton and Brennan	119	517	4.74	2,510
June 6	M. S. Brennan	120	250	3.71	988

Daily gage height, in feet, of Oconto River at Stiles, Wis., for 1906.

Day.	Apr.	May.	June.	Day.	Apr.	May.	June.
1		4.0	3.0	17		3.8	
2		3.8	2.4	18		4.0	
3		3.6	3.2	19		4.4	
4		3.8	2.5	20	4.9	2.6	
5		3.3	2.7	21	4.8	4.0	
6		4.5	2.8	22	4.7	4.1	
7		2.8		23	4.4	4.0	
8		4.5		24	4.6	4.1	
9		4.2		25	4.6	3.3	
10		4.2		26	4.8	3.7	
11		4.1		27	4.6	2.8	
12		4.4		28	4.3	3.3	
13		4.7		29	3.8	2.3	
14		3.4		30	3.8	3.1	
15		4.4		31		3.3	
16		4.2					

WOLF RIVER SYSTEM.

General Conditions.

Wolf River rises in a number of lakes about 25 miles south of the Michigan boundary and flows in a general southerly direction, entering upper Fox River at a point about 10 miles west of Lake Winnebago. Though nominally a branch of Fox River, it is in reality the master stream, having over three times the discharge. Wolf River receives all its important tributaries from the west and at points relatively near its mouth. It has been elsewhere noted (p. 64) that there is much evidence that the river formerly ran west and joined Mississippi River through the present Wisconsin River Valley between Portage and Prairie du Chien.

In the upper half of its course Wolf River has formed its bed in the pre-Cambrian crystalline rocks, and in this distance the descent of the river is very rapid. At the Chicago and Northwestern railway crossing, 2 miles west of Lenox, the river has an elevation of 1,562 feet above the sea. In the 80 miles between this point and Shawano the river descends 774 feet, or 9.7 feet per mile. This steep gradient causes many rapids and falls. Plate XIII gives views of the dam and rapids at the Dells of the Wolf. Lumbering dams have been maintained in the upper river at the following points:[1] Sec. 9, T. 33 N., R. 12 E.; Lilly dam, Sec. 34, T. 33 N., R. 13 E.; Sec. 10, T. 31 N., R. 14 E.; Sec. 25, T. 31 N., R. 14 E., and at several other places lower down. In the 40 miles above Shawano small undeveloped powers of 10 to 15 feet head are of frequent occurrence.

Shawano, the head of navigation on the river, and county seat of Shawano County, has a population of 2,000. A dam is located at

[1] Wisconsin Geological Survey maps.

this point, with a head of 12 feet, and is used to grind wood pulp. Shawano also marks the point of transition from the pre-Cambrian to the Cambrian sandstone. It is at this point that the river crosses the old coast line of Lake Michigan and enters the region of red clay. Below Shawano the stream is sluggish, its descent being only about 42 feet to Lake Winnebago, a distance of about 80 miles. The banks are low, and in high water the surrounding flats are all covered, the river sometimes expanding at time of heavy freshets to several miles in width. For obvious reasons there can be no water powers in this lower region.

The profile of Wolf River for 160 miles of its course is shown in the following table:

Profile of Wolf River, Wisconsin, from mouth to near Lenox.

Station.	Distance from mouth.	Elevation above sea level.	Authority:
	Miles.	*Feet.*	
Winneconne	.....	746.4	United States Engineers.
New London	33	749.5	Chicago and Northwestern Railway
Shawano	80	788.0	Do.
Lenox	160	1,562.5	Do.

RUN-OFF.

The following tables showing gage-height observations and discharge measurements at Winneconne and near Northport, on Wolf River, are from data published by the United States Geological Survey:

Discharge measurements of Wolf River Winneconne, Wis., in 1903.

Date.	Hydrographer.	Gage heighth.	Discharge.
		Feet.	*Second-feet.*
January 5[1]	L. R. Stockman	5.50	904
January 24[1]	do	5.30	1,436
February 20	do	5.00	1,285
March 24	do	6.60	9,998
April 15	do	6.90	3,808
May 11	do	6.70	3,537
June 20	do	6 40	3,194

[1] River frozen.

Mean daily gage height, in feet, of Wolf River at Winnecone, Wis., January 1 to July 25, 1903.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	5.50	5.30	4.80	7.10	6.60	7.00	6.10
2	5.50	5.30	4.80	7.20	6.65	7.00	6.10
3	5.50	5.30	4.80	7.20	6.70	7.00	6.10
4	5.50	5.20	4.80	7.10	6.65	6.90	6.10
5	5.50	5.20	4.80	7.10	6.60	6.80	6.10
6	5.50	5.20	4.90	7.10	6.65	6.80	6.10
7	5.50	5.20	4.90	7.05	6.70	6.85	6.20
8	5.50	5.20	4.90	6.90	6.70	6.80	6.20
9	5.50	5.20	4.90	6.80	6.70	6.80	6.20
10	5.50	5.10	5.00	6.95	6.70	6.80	6.30
11	5.50	5.10	5.00	7.10	6.80	6.70	6.30
12	5.50	5.10	5.10	7.00	6.80	6.70	6.30
13	5.50	5.10	5.25	7.00	6.80	6.60	6.30
14	5.50	5.10	5.30	6.90	6.80	6.60	6.30
15	5.50	5.00	5.60	6.80	6.80	6.60	6.30
16	5.50	5.00	5.70	6.85	6.80	6.50	6.30
17	5.50	5.00	5.80	6.90	6.80	6.50	6.30
18	5.40	5.00	5.90	6.80	6.80	6.45	6.40
19	5.40	5.00	6.00	6.80	6.80	6.45	6.40
20	5.40	5.00	6.20	6.75	6.80	6.40	6.40
21	5.40	4.90	6.30	6.70	6.80	6.40	6.30
22	5.40	4.90	6.40	6.80	6.80	6.40	6.30
23	5.40	4.90	6.50	6.80	6.80	6.30	6.20
24	5.40	4.90	6.60	6.80	6.85	6.30	6.20
25	5.40	4.90	6.70	6.80	6.90	6.20	6.10
26	5.40	4.80	6.80	6.80	6.90	6.20	.....
27	5.30	4.80	6.90	6.70	7.05	6.10	.....
28	5.30	4.80	6.90	6.70	6.90	6.10	.....
29	5.30	.....	6.90	6.65	7.00	6.10	.....
30	5.30	.....	7.00	6.60	7.00	6.10	.....
31	5.30	.....	7.10	.....	7.00	.....	.....

Discharge measurements of Wolf River near Northport, Wis., in 1905.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
April 5	F. W. Hanna	182	2,642	2.64	7.03	6,965
May 22	S. E. Clapp	171	2,198	1.8	4.65	3,964
June 17	M. S. Brennan	151	2,553	1.97	6.42	5,032
July 15	do	176	2,300	1.69	5.06	3,885
August 16	do	176	2,053	1.26	3.01	2,594
September 22	F. W. Hanna	172	1,978	1.41	3.6	2,781

Mean daily gage height, in feet of Wolf River near Northport, Wis., April 6 to December 30, 1905.

Day.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.40	6.00	3.30	3.00	1.60	1.55	1.30	1.70
2	.....	3.60	5.00	3.00	2.30	2.40	1.40	1.40	1.60
3	.....	3.80	5.00	3.40	2.20	2.60	1.35	1.50	1.40
4	.....	4.00	4.90	3.60	2.10	2.20	1.30	1.60	1.50
5	.....	4.20	4.60	3.80	2.30	3.10	1.15	1.70	1.60
6	6.90	4.40	5.60	3.30	2.20	3.40	1.10	1.95	1.75
7	6.80	4.60	5.40	4.30	2.40	3.60	.90	2.10	1.80
8	6.70	4.80	5.30	4.60	2.90	3.30	.85	2.30	1.90
9	6.60	4.80	5.80	4.60	3.30	3.40	.70	2.50	2.10
10	6.50	5.00	5.80	4.90	4.00	3.60	.65	2.70	2.00
11	6.40	5.00	5.80	5.00	3.50	3.80	.60	2.60	1.90
12	6.30	5.20	5.90	5.20	3.60	3.50	.50	2.40	1.95
13	6.10	5.60	6.10	5.10	3.60	2.80	.35	2.30	1.80
14	6.00	5.80	6.40	5.10	3.00	2.50	.10	2.20	1.60
15	5.80	5.60	6.40	4.90	3.00	2.70	.25	2.10	1.40
16	5.60	5.50	6.60	4.20	3.50	2.90	.40	1.80	1.30
17	5.50	5.30	6.50	4.60	3.50	2.80	.75	1.50	1.20
18	5.20	5.30	6.40	4.30	3.30	3.00	.90	1.40	1.10
19	5.20	5.20	6.40	4.80	3.20	3.40	1.15	1.30	1.00
20	4.90	5.00	6.20	4.60	3.00	.....	1.50	1.20	1.00
21	4.80	4.80	6.00	4.45	2.80	2.90	2.20	1.10	1.00
22	4.80	4.60	5.80	4.20	2.40	2.80	2.60	1.00	1.00
23	4.30	4.60	5.60	4.10	2.50	3.70	2.90	.90	.90
24	4.10	4.80	5.30	4.00	2.30	3.60	3.20	.80	.90
25	4.00	5.00	5.10	3.30	2.00	3.40	3.40	.60	.75
26	3.80	5.00	4.70	3.60	1.80	3.25	3.30	.40	.60
27	3.60	4.60	4.40	2.80	1.60	3.10	3.20	.20	.50
28	3.50	4.30	4.00	2.50	1.40	2.90	3.00	.60	.50
29	3.50	5.40	3.80	2.30	1.20	2.75	2.10	.80	.40
30	3.40	5.60	3.50	2.20	1.10	2.35	2.30	1.90	.40
31	.....	5.80	.....	2.00	1.00	.....	2.00	.....	.....

WOLF RIVER AT DARROW'S BRIDGE, NEAR SHAWANO, WIS.

A station was established April 21, 1906, at Darrow's bridge, about 2 miles south of Shawano, and was discontinued June 6, 1906, as the dam above modified the flow.

A measurement was made April 21, 1906, by Horton and Brennan, with the following results:

Width, 188 feet; area, 1,350 square feet; gage height, 5.87 feet; discharge 3.890 second-feet.

Fig. 1. TWIN FALLS. PESHTIGO RIVER.

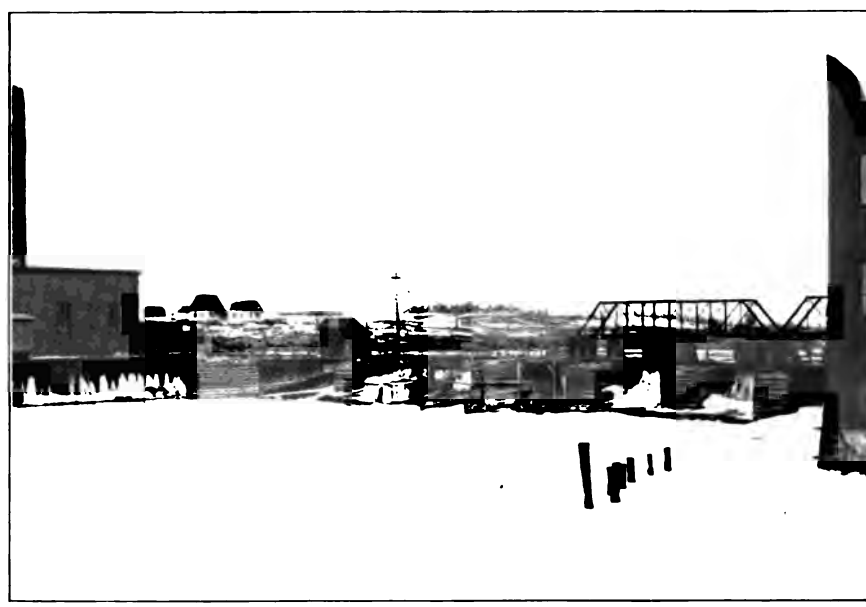

Fig. 2. DAM AT SHAWANO, WOLF RIVER.

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Daily gage height, in feet, of Wolf River at Darrow's bridge, near Shawano, Wis., for 1906.

Day.	Apr.	May.	June.	Day.	Apr.	May.	June.
1	.....	4.7	4.8	17	.....	4.8	.....
2	.....	4.7	4.3	18	.....	4.1	.....
3	.....	4.5	.....	19	.....	4.1	.....
4	.....	4.0	3.8	20	.....	.....	.....
5	.....	4.8	.....	21	.....	6.1	4.2
6	.....	.....	.....	22	.....	.....	3.6
7	.....	4.6	.....	23	.....	5.4	3.9
8	.....	4.7	.....	24	.....	5.3	3.8
9	.....	4.3	.....	25	.....	5.0	4.2
10	.....	4.6	.....	26	.....	4.7	4.2
11	.....	3.5	.....	27	.....	4.7	.....
12	.....	4.2	.....	28	.....	4.6	3.6
13	.....	.....	.....	29	.....	.....	5.2
14	.....	4.8	.....	30	.....	4.5	5.0
15	.....	4.8	.....	31	.....	.....	4.3
16	.....	4.7	.....				

WOLF RIVER AT WHITE HOUSE BRIDGE, NEAR SHAWANO, WIS.

This station was established June 6, 1906. It is located at the "White House" highway bridge, about 3½ miles north of Shawano, Wis.

The channel is straight for about 200 feet above and 500 feet below the station. Both banks are of medium height and do not overflow. The bed of the stream is gravel and is permanent. There is one channel at all stages. The current is medium swift. This station may be affected by back water from the dam about 4 miles below.

A standard chain gage, which is read daily by Albert Utke, is fastened to the guard rail on the upstream side of the bridge; length of chain, 16.25 feet. The reference point is the center of gage pulley; elevation, 16.07 feet above gage datum.

Discharge measurements of Wolf River near Shawano, Wis., in 1906.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Sq. ft.*	*Feet.*	*Sec.-ft.*
June 6	M. S. Brennan	136	767	6.90	1,970
June 30	do	132	629	5.96	590

The above station proved unsatisfactory so a new station was established at Keshena.

Daily gage height, in feet, of Wolf River near Shawano, Wis., for 1906.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	6.5	6.5	5.8	6.8	7.7
2	.....	6.9	6.3	.....	5.8	6.7	... (1) ..
3	.....	8.2	6.4	6.5	5.9	6.6	.....
4	.....	7.6	6.2	6.6	6.0	.....	.....
5	6.9	7.6	.....	6.4	6.1	6.2	.....
6	7.4	7.4	6.2	6.2	6.0	6.4	.....
7	7.7	7.3	6.2	6.1	.....	6.8	.....
8	7.9	.....	6.0	5.9	6.3	6.5	.....
9	7.7	7.1	5.9	.....	6.1	6.1	.....
10	7.7	6.4	6.0	6.0	6.1	6.4	.....
11	7.1	6.5	6.7	6.4	6.4	.....	.....
12	6.9	6.4	.....	6.4	6.4	6.2	.....
13	7.0	6.8	6.2	6.2	6.0	5.9	.....
14	6.5	6.9	6.2	6.1	.....	6.6	.....
15	6.8	.....	6.0	6.3	6.1	6.3	.....
16	6.6	6.5	6.0	.....	6.1	6.3	.....
17	6.6	6.3	6.5	7.0	6.0	6.6	.....
18	6.5	6.0	6.3	6.6	6.3	.....	.....
19	6.7	6.2	.....	6.6	6.3	6.7	.....
20	6.5	5.8	6.0	6.4	6.9	7.2	.....
21	6.9	6.3	5.9	6.3	.....	7.0	.....
22	7.2	.....	6.0	6.4	6.5	7.3	.....
23	6.8	6.4	6.3	.....	6.3	7.3	.....
24	.....	6.1	6.2	6.1	6.6	7.2	.....
25	6.0	5.7	6.0	6.2	6.9	.....	.....
26	6.7	6.1	.....	6.1	6.7	8.1	.....
27	6.6	6.2	6.7	6.0	6.7	8.1	.....
28	6.5	6.2	6.4	5.9	.....	7.4	.....
29	6.4	.....	7.2	5.8	6.7	7.6	.....
30	5.8	5.8	6.2	.....	6.5	7.1	.....
31	.....	6.0	5.8	.....	6.6	.....	.....

[1] Frozen.

KESHENA, WIS.

This station was established May 9, 1907. The station is situated 8 miles north of Shawano, Wis., at a small town called Keshena. It is located on a highway bridge 50 rods southwest of the Green Bay agency office on the Menominee reservation.

The general direction of the channel is straight for 2,000 feet above station and also 200 feet below. The water moves slowly. The average width at ordinary stage is 120 feet broken by one small pier.

(Looking down stream) the right bank is high and wooded and will not overflow. The left bank is low and during high stages of river is liable to overflow. The bed is composed of stone and gravel and does not shift. There is one channel at all stages.

Discharge measurements are made from this bridge to which the gage is attached. The initial point of sounding is directly over left abutment of bridge on downstream side. It is marked by black paint.

The Dells of Wolf River.

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A staff gage, which was read by Adam Neff during 1907, is fastened to left end of bridge on downstream side. The gage is made of a pine board 8.5 feet long. Feet and tenths of feet are painted on the gage with black paint. The gage is referred to following bench marks:

(1) (Looking down stream.) *Cross* on a post at end of fence at left end of bridge on down stream side of road is 9.38 feet above zero of gage.

(2) *Cross* on a stump at left end of bridge on down stream side of road about 3 rods N. E. of bridge is 6.54 feet above zero of the gage.

(3) *Cross* on a telephone pole ten rods N. E. of bridge at end of road crossing the bridge is 9.04 feet above zero of gage.

Mean daily gage height in feet, of Wolf River at Keshena, Wis., for 1907.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.85	1.95	1.4	1.15	1.7	1.6	1.6
2	.....	3.35	2.25	1.6	1.8	1.6	1.6	1.6
3	.....	1.4	1.85	1.15	1.4	1.8	1.65	2.65
4	.....	2.85	2.05	3.2	2.25	2.35	1.8	2.4
5	.....	2.4	1.5	2.1	1.2	1.95	1.8	2.2
6	.....	2.55	2.6	1.6	2.35	2.2	1.6	2.2
7	.....	2.65	1.95	1.75	2.35	1.95	1.6	2.2
8	.....	2.3	2.5	1.45	1.3	2.0	1.6	2.2
9	... (1) ..	2.55	2.75	1.5	3.1	1.9	1.6	2.25
10	3.00	1.0	1.1	1.5	3.25	1.9	1.6	2.2
11	3.32	2.0	2.55	1.55	2.6	1.95	1.7	1.95
12	3.7	2.25	1.15	1.9	2.4	1.9	1.65	1.85
13	1.77	1.9	1.25	1.8	2.15	1.85	1.65	2.25
14	3.75	1.6	1.4	1.85	1.9	1.8	1.65	2.5
15	4.29	1.9	3.05	1.85	1.7	1.8	1.55	2.55
16	4.45	1.85	2.95	1.85	1.8	1.8	1.5	2.55
17	4.65	1.45	1.0	1.75	1.8	1.8	1.6	2.7
18	4.35	2.2	3.2	1.95	1.8	1.75	1.65	3.0
19	4.75	1.7	1.15	1.85	2.8	1.7	1.6	2.95
20	3.7	1.6	2.9	1.45	4.25	1.7	1.6	2.95
21	3.85	1.8	1.15	2.0	4.3	1.7	1.85	3.35
22	3.8	2.0	2.5	2.0	3.65	1.65	1.9	3.4
23	3.55	1.85	2.35	1.3	3.25	1.80	1.8	3.4
24	3.5	1.7	1.15	1.45	3.05	1.55	1.7	3.4
25	3.45	1.9	2.55	1.2	2.5	1.7	1.7	3.45
26	3.4	2.2	1.4	1.95	2.4	1.7	1.7	3.4
27	3.05	1.55	2.7	2.35	2.3	1.65	1.7	3.45
28	3.45	1.7	1.15	1.8	2.15	1.65	1.7	3.4
29	3.3	1.55	2.55	1.9	2.1	1.7	1.7	3.4
30	3.15	1.65	1.0	1.1	1.75	1.6	1.6	3.5
31	2.9	.....	2.8	2.2	.....	1.6	.....	3.65

[1] Station established.

The following discharge measurements at Keshena were made in 1907:

The drainage area about Keshena is 794 square miles.

1907.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 22	G. A. Gray	105	308	2.10	1.81	666
July 20	do	104	481	3.14	3.32	1,491
Aug. 24	do	107	277	1.99	2.05	568
Oct. 12	do	109	320	2.24	1.90	737
Nov. 8	do	109	385	2 54	2.5	1009
Dec. 14	do	109	368	1.88	2.5	694

December 14 measurement made under half frozen and half open conditions. Velocity obtained by floating ice.

Discharge measurements under ice Wolf River at Keshena, Wis.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height. Water sur.	Discharge	Av. th. of ice	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec-ft.		
1908.	G. A. Gray	101	290	1.75	3.25	509	1.5	.3
January 18	do	103	217	1.77	3.05	385	1.7	1.5
February 6	do	103	257	2.05	3.2	529	1.9	.5
March 7	do	103	257	2.04	3.2	523	1.9	.5

Record of thickness of ice at Keshena.

		Feet
Jan. 18.	River closed.	
Jan. 21.	Average thickness of ice	1.2
Jan. 28.	Average thickness of ice	1.2
Feb. 4.	Average thickness of ice	1.5
Feb. 11.	Average thickness of ice	1.4
Feb. 18.	Average thickness of ice	1.4
Feb. 25.	Average thickness of ice	1.4
Mar. 3.	Average thickness of ice	1.4
Mar. 10.	Average thickness of ice	1.7
Mar. 17.	Average thickness of ice	1.3
Mar. 21.	Average thickness of ice	1.2

Note: Ice went out March 29.

LITTLE WOLF RIVER.

Little Wolf River is one of the largest branches of Wolf River. It has a drainage area of 475 square miles. Like all the streams in this region the river has its greatest fall in the upper third of its length, but even in its lower third there is sufficient fall to insure important water powers. Recent surveys by Mr. D. W. Mead show

that the river has a fall of 62 feet in the sixteen miles above its mouth, distributed as shown in the following profile:

Description of station.	Distance from mouth.	Elevation above the sea.
	Miles.	*Feet.*
North of river	0	748.0
Phillips' Bridge	2	751.5
Ostander Bridge	3.3	762.0
Royalton Bridge	6.0	773.5
Mouth of South Branch	9.0	779.2
Little Wolf Dam, below	9.6	783.0
Do above	9.6	790.5
Lower Manawa Bridge	.....	793.0
Manawa Bridge, below	11.3	796.0
Do above	11.3	806.8
Symco Dam, below	16.3	820.8

NOTE. – These elevations are only approximately referred to sea level.

WATER POWERS.

Phillips.—Surveys have shown that a head of 20 feet can be obtained at Phillips which for a ten hour day should give about 850 horsepower. A measurement of the river here shows a low water flow of 215 cubic feet per second. This dam would use all the available fall between Phillips and Royalton.

Royalton.—The banks are sufficiently high at Royalton to allow of an 18-foot dam, although this would drown out the present power at Little Wolf. An eighteen foot head would develop on a 10 hour day basis about 750 horsepower.

Manawa.—At present a dam at Manawa develops a head of about 11 feet. As there is a fall of about 14 feet in the five miles above Manawa it seems probable that this dam could be raised to at least 15 feet.

A statement of other powers on this river will be found in the following table:

TRIBUTARIES OF WOLF RIVER.

The lower part of the Wolf River drainage area is more thickly settled than the upper, and as a result the tributaries which occupy this lower portion are rather fully developed. This is especially true of Embarrass, Little Wolf, and Waupaca rivers.

Water Powers.

The following table shows the water powers on Wolf River and its tributaries:

Water on Wolf River and its tributaries.

Location and stream.	Owner and use.	Head.	H. P.
		Feet.	
Manawa, sec 15, T. 23 N., R. 13 E., Little Wolf River.	Little Wolf River Lumber Co., grist, lumber electric light.	10	390
Littlewolf, sec. 34, T. 23 N , R. 13 E., Little Wolf River.	Booth & Smith, grist, lumber, electric light.	9	60
Scandinavia, south branch Little Wolf River.	Henry Peterson, feed mill.....	8	23
Sec. 22, T. 23 N., R. 11 E., south branch of Little Wolf River.	J. 1. Wralstatt, feed mill.....	9	50
Phlox, sec. 26, T. 30 N., R. 12 E , Red River.	J. Kaufman, saw and planing mill.	14	75
Mount Morris, sec. 16, T. 19 N , R. 11 E., Rattlesnake Creek.	Wm. Kemp, grist mill...	12	44
Wittenberg, Sec. 10, T. 27 N., R. 11 E., Embarrass River.	Viking Lumber Co., sawmill.....	12	75
North branch of Embarrass River.....	N. M. Edwards, sawmill.....	13	50
Sec. 7, T. 26 N., R. 13 E., Embarrass River	N. M. Edwards, undeveloped.....	20	.....
Embarrass, sec. 5, T. 25 N., R. 15 E., Embarrass River.	Decker & Beedle, lumber and planing mill.	8	115
Sec. 23, T. 26 N., R. 13 E., middle branch of Embarrass River.	Theo. Boettner, flouring mill.....	9	200
Sec. 15, T. 27 N., R. 15 E., north branch of Embarrass River.	Seiber & Dumke, sawmill.....	13	192
Sec. 23, T. 28 N., R. 12 E., north branch of Embarrass River.	L. A. Weikel, saw, planing, and feed mill.	16	116
Pilla, sec. 9, T. 26 N., R. 14 E , Embarrass River.	Grosskopt, saw and planing mill...	13	60
Sec. 9, T. 27 N., R. 12 E., middle branch of Embarrass River.	Buckstaff Lumber Co., power house burned.	10	.....
Waupaca, sec. 32, T. 22 N., R. 12 E., Crystal River.	Waupaca woolen mills.....	8	35
Waupaca, sec. 20, T. 22 N., R, 12 E., Waupaca River.	A. G Nelson, planing and grist mill.	6½	65
City of Waupaca, Waupaca River.....	Electric Light Co	18	200
Do....	Undeveloped.....	15	.....
Sherman, sec. 18, T. 22 N., R. 11 E., Waupaca River.	Brooks & Root, flouring mill.....	7	100
Weyauwega, sec. 4, T. 21 N., R. 13 E., Waupaca River.	Weed Gunnard, flour, planing, and electric light.	10	480
Waupaca, Waupaca River.....	C. Gurines, brick manufacture.....	8	50
Amherst, Spring Creek	N. Howard, feem mill.....	10	20
Rural, sec. 10, T. 21 N., R. 11 E., Arbor Creek.	J. Ashmun, flouring and saw mill..	9	96
Gresham, sec. 3, T. 27 N., R. 14 E., Red River.	A. G. Schmidt, sawmill.....	11	100
Sec. 6, T. 27 N., R. 15 E.. Red River.....	Undeveloped.....	.....	.....
Sec. 19, T. 27 N., R. 14 E., Red River.....	....do.....	.....	.....
Sec. 18, T. 28 N., R. 14 E.. Red River.....	.. do.....	.....	.....
Sec. 15, T. 26 N., R. 10 E., Little Wolf River.	Little Wolf River Lumber Co., logging.	7	0
Sec. 7, T. 25 N., R. 11 E., Little Wolf River.	. . .do.....	7	0
Sec. 5, T. 24 N., R. 13 E., Little Wolf River.	....do.....	7	0.
Sec. 9, T. 33 N., R. 12 E., Wolf River.....	Used for logging...	.....	.....
Sec. 34, T. 33 N., R. 13, E., Wolf River....	....do.....	.....	.....
Sec. 10, T. 31 N., R. 14 E., Wolf River....	....do..., ...	.....	.....
Sec. 25, T. 31 N., R. 14 E., Wolf River....	....do.....	.....	.....

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WISCONSIN RIVER SYSTEM.

Topography and Drainage.

Because of its length, its great drainage area, and its central location Wisconsin River is preeminently the main river of the State.

Like the Flambeau, the headwaters of Wisconsin River are found in an intricate network of lakes and swamps occupying the flat plateau region near the northern boundary. Its extreme source is found in Lake Vieux Desert, a body of water of about 10 square miles on the line separating the northern peninsula of Michigan from Wisconsin, at about 1,650 feet above sea level. The general course of the river for the first 300 miles is south. At a point near Portage it turns abruptly westward, and in the next 100 miles flows nearly west, joining Mississippi River at Prairie du Chien, only 40 miles from the southern boundary of the State.

Because of its long traverse from the extreme northern to the extreme southwestern part of Wisconsin the topography of the basin includes nearly every form found in the State. Like the upper Chippewa Valley, the northern half is a densely wooded region of hard and soft timber except where cleared for farming. The woods gradually give way to a semi-prairie region with a gently undulating surface, but with occasional decided ridges both of rock and glacial origin. A very striking surface feature toward the southern part is found in the "Baraboo quartzite" ranges, which have an elevation of from 400 to 700 feet above the surrounding country. These ranges comprise two main ridges from 4 to 6 miles apart, extending nearly east and west in the section of country west of Portage for about 25 miles, but uniting and ending abruptly on the west side of the valley, near Portage. The angle of the river at this point seems due to its effort to secure a passage around this rock barrier.

The drainage basin includes 12,280 square miles, with an average width of 50 miles and a length of about 225 miles. The apportionment of this drainage area among the several tributaries of Wisconsin River is shown in the following table:

Distances and drainage areas of Wisconsin River.

River.[1]	Distance.		Drainage area above station.
	From course.	Between stations.	
	Miles.	*Miles.*	*Sq. miles.*
Pelican, above mouth	.....	60	940
Pelican, mouth	60	0	1,202
Tomahawk	85	25	2,111
Prairie	113	28	2,697
Rib, above mouth	.....	23	3,192
Rib, mouth	136	0	3,690
Eau Claire	138	2	4,114
Eau Pleine, above mouth	.....	20	4,268
Eau Pleine, mouth	158	0	4,645
Little Eau Pleine	166	8	5,005
Plover	184	18	5,300
Yellow, above mouth	.....	64	6,448
Yellow, mouth	248	0	7,394
Lemonweir	259	11	8,172
Baraboo	292	33	9,095
Above mouth of Kickapoo river	389	97	11,387
Mouth of Kickapoo river	.....	0	12,159
Mouth of Wisconsin river	407	18	12,280

[1] Station is at mouth of river unless otherwise stated, from 10th census.

Through a portion of the city of Portage and southward, the river can hardly be said to have an eastern divide. Fox River approaches within 1½ miles of the Wisconsin at this point, only a low marsh intervening. Even this marsh has a slope of about 3 feet toward Fox River. At the present time levees at this and other points prevent the Wisconsin at times of high water from overflowing into Fox River. These levees for a distance of several miles compel the river to flow along the contour instead of in the direction of maximum slope. The reasons for this and other peculiarities of its valley are interestingly discussed in Geology of Wisconin, (vol. 3):

"It is evident that such an uncertain divide as this can not have formed one of the original permanent features of the drainage of the region, but as the disposition of the surface soil is due to glacial action, modified by subsequent erosion and transportation, this may be fairly attributed to such a cause. The rampart of limestone which compels the lower Wisconsin to flow west does not stop south of Portage, but continues east and north, although less prominent, form-

ing an eastern barrier to the flow of the Wolf River. The course of the upper Fox to Lake Winnebago is sluggish, consisting largely of marshes and lake-like expansions. On account of the depression of the divide at Portage, the continuation of the southern barrier northeast, the small slope of the upper Fox, the large trough of the Wisconsin below Portage, which it is unable to occupy, while above the river is more nearly in proportion to its channel of drainage, and finally the evidently modern outlet for the Wolf and the upper Fox through the lower Fox—the conclusion is reasonable, if not inevitable, that at one time the Lake Winnebago system drained southwest into the Mississippi and the Wolf was the true continuation of the Wisconsin above Portage, while the present upper Wisconsin was merely a tributary of the main stream."

LAKE ELEVATORS AND RESERVOIR SITES.

Attention has elsewhere been called (p. 11) to the opportunity of increasing the low-water flow of the northern rivers by the construction of dams near the headwaters for use as reservoirs. The opportunity for such a system on Wisconsin River is especially good, because the ownership of the lands to be flooded is in the hands of a comparatively few corporations and a beginning has already been made. For example, a well-built dam at the foot of the Tomahawk chain of lakes, which impounds water covering many square miles of reservoir, has been used for several years to regulate the stage of the river for the mills below the mouth of the Tomahawk. In scores of cases the dams are already constructed for logging purposes and need only to be kept in repair to be of service for power regulation when they are no longer needed for their original purpose, as will soon be the case.

It has been proposed to build or maintain dams at the following points: Lake Vieux Desert, Sec. 17, T. 42 N., R. 11 E.; Twin Lakes, Sec. 19, T. 41 N., R. 11 E.; Eagle Lakes, Sec. 31, T. 40 N., R. 10 E.; Sugarcamp Lakes, Sec. 17, T. 39 N., R. 9 E.; Buckataban Lakes, Sec. 24, T. 41 N., R. 9 E., Little St. Germain Lake, Sec. 2, T. 39 N., R. 8 E.; Big St. Germain Lake, Sec. 18, T. 39 N., R. 8 E.

At many if not most of the larger lakes near the headwaters, logging companies have long maintained dams, which some day will serve the double purpose of reservoirs and sources of power. A list

of some of these lakes, together with their elevation above the sea, as determined by United States engineers, is given in the following table:

Lakes at headwaters tributary to Wisconsin River.

Name of lake.	At headwaters of—	Elevation above sea level.
		Feet.
Eagle	Eagle River	1,582.0
Catfish	do	1,583.0
Cranberry	do	1,583.5
Long	do	1,592.2
Planting Ground	do	1,592.2
Fish	do	1,592.2
Medicine	do	1,592.2
Stone	do	1,592.2
Dog	do	1,592.2
Big	do	1,592.2
Pelican	Pelican River	1,590.0
Tomahawk	Tomahawk River	1,562.2
Island	do	1,560.4
Keawasogan	do	1,560.4
Mud	do	1,553.4
Squirrel	do	1,542.9

The following table gives dimensions and other data of eight reservoir sites surveyed by United States engineers as an aid to navigation on Mississippi River:

Proposed United States Government reservoirs on Wisconsin River.

Name.	Location.			Elevation of low water at dam site.	Maximum dimensions.				Reservoir.		Area of watershed.
					Dam.		Dike.				
	Section.	Township.	Range.		Length.	Height.	Length.	Height.	Area.	Capacity.	
				Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq mi.*	*Cubic feet.*	*Sq. mi.*
Pelican	6	36 N.	9 E.	1,520.83	800	28	3,625	15	13.45	5,153,180,527	301.0
Sugarcamp	17	39 N.	9 E.	1,562.00	235	12.5	260	4	5.00	1,356,284,160	60.0
Ottor Rapids	36	40 N.	9 E.	1,578.07	1,300	22	700	5	30.74	7,389,727,488	447.0
Tomahawk	7	39 N.	6 E.	1,554.67	190	12	.....	.....	13.46	2,226,113,036	101.5
Squirrel	1	38 N.	5 E	1,521.78	315	17	.....	.....	5.30	1,338,163,200	56.0
Rice	9	35 N.	6 E.	.....	1,100	14	.....	.....	6.00	1,043,516,880	396.0
Vieux Desert	17	42 N.	11 E.	.....	.....	.....	.....	.....	7.00	400,000,000	19.0
Twin Lakes	19	41 N.	11 E.	.....	.....	.....	.....	.....	6.50	650,000,000	30.0
									87.45	19,556,985,291	1,410.5

Subsequent to this report two of these dams, at Rhinelander (Pelican) and Tomahawk, have been constructed by private enterprise for power purposes; several others have been constructed with reduced heads. It will be noted that the proposed Government reservoirs have a total area of 87.45 square miles and a drainage area of 1,410½ square miles. It was proposed to fill the reservoirs during the spring freshets and then allow the water to escape at times of low water. The United States engineers estimated that these reservoirs would maintain a flow of 3,000 second-feet for three months of the year. Such a flow would nearly double the present low-water flow of the river and its resulting water power. Incidentally the use of such reservoirs would to a large extent serve to reduce the dangers of high floods, both to dams and to overflowed lands. It would, in fact, tend to restore the regimen of the river to that which it possessed before deforestation and cultivation began to transform a great primeval forest region into cleared and well-cultivated fields.

The first systematic effort to enlarge these reservoirs was made by interested parties in 1905 and a bill was drafted which it was claimed gave unusual rights and powers to a certain few. This bill failed to become a law. At the time of the following legislature, 1906–7, a much more carefully prepared bill was enacted into law as Chapter 335 of the laws of 1907. This law authorizes the Wisconsin Valley Improvement company to construct, acquire and maintain a system of water reservoirs located on the tributaries of the Wisconsin River north of the south line of Township 34 for the purpose of producing a uniform flow of water, etc. Section four of this act provides that when this company shall have created reservoirs of a capacity of two billion cubic feet, it may collect and receive reasonable tolls from the owners of every improved and operated water power located on the river below such reservoirs. The said tolls are to yield not to exceed 6 per cent on the actual investment.

The law gives the company until January, 1909, to have in operation reservoirs with a capacity of two billion cubic feet. This, however, is but a small proportion of the 19 billion cubic feet planned by the U. S. Engineers but it is a beginning of an important improvement.

PROFILE.

According to the United States engineers, the elevation of Lake Vieux Desert is about 1,650 feet, while the elevation of the mouth

of Wisconsin River at Prairie du Chien is 604 feet at low water or 625 feet at high water. This gives a total descent of about 1,046 feet in an estimated length of 429 miles, or about 2½ feet per mile. About 634 feet of this fall occur in the 150 miles between Rhinelander and Nekoosa, an average of 4.23 feet per mile. This descent is concentrated at many places, producing a large number of valuable water powers, many of which have been improved and used by important industries.

The fall in the main tributaries is even greater in many cases than that in the parent stream, and owing to this fact, and also to the absence of lakes and swamps, it is likely that their discharge is subject to great extremes.

A detail profile of Wisconsin River is given in the following table prepared from surveys:

Profile of Wisconsin River.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river, low water.....	0	0	604	.....	.....
2	Muscoda Bridge	43.5	43.5	669	65	1.5
3	Prairie du Sac	93.5	50.0	740	71	1.4
4	Merrimac	102	8.5	754	14	1.6
5	Portage	117.5	15.5	784	30	1.9
6	Kilbourn, below dam	138	20.5	815	31	1.5
7	Lemonweir R., mouth of	148.5	10.5	836	21.0	2.0
8	Yellow R., mouth of	159.5	11.0	858	22.0	2.0
9	Petenwell Bridge, opposite Necedah	174.5	15.0	878.5	20.5	1.36
10	Nekoosa Dam, delow dam	207.6	33.1	921.8	43.3	1.38
11	Nekoosa Dam, above dam	.....	.....	938.8	17.0	.....
12	Edwards Dam, below dam	211.1	3.5	948.5	9.7	2.8
13	Edwards Dam, above dam	.....	.....	958.5	10.0	.....
14	South Ceatralia Dam, below ..	212.6	1.5	962.0	3.5	2.3
15	South Ceatralia Dam, above ..	.....	.....	971	9	.....
16	Grand Rapids Dam, below	215.1	2.5	982	11.0	4.4
17	Grand Rapids Dam, above	.....	.....	1004	22	.....
18	Biron Dam, below	218.6	3.5	1008	4	1.3
19	Biron Dam, above	.....	.....	1018	10	.....
20	Plover Paper Mill Dam, below	231.6	13.0	1034.3	10.7	1.2
21	Plover Paper Mill Dam, above	.....	.....	1040.8	10.6	.....
22	Wis. R. Paper & Pulp Co. Dam, below	232.3	0.7	1044.3	0.7	1.0
23	Wis. R. Paper & Pulp Co. Dam, above	.....	.....	1060.9	16.6	.....
24	Stevens Point W. C. Bridge ..	234.8	2.5	1066.0	5.1	2.0
25	Jackson Milling Co. Dam, below	235.0	0.2	1069.7	3.7	11.75
26	Jackson Milling Co. Dam, above	.....	.....	1076.7	7.0	.....

Profile of Wisconsin River—Continued.

No.	Station.	Distance. From mouth.	Distance. Between points.	Elevation above sea level.	Descent between points. Total.	Descent between points. Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
27	Little Eau Pleine River	250.7	15.7	1089.0	12.3	0.8
28	Knowlton C., M. & St. P. R. R. bridge	256	5.3	1097.6	8.6	1.6
29	Line between Rs. 6 & 7 E.	263	7	1106	8.4	1.2
30	Mosinee Highway bridge	265.2	2.2	1114	8	3.7
31	Mosinee Dam, foot	265.4	0.2	1122.0	8.0	40
32	Mosinee Dam, crest	.....	.....	1127.7	5.7	.....
33	Black Creek, mouth	268.8	3.4	1129.3	1.6	0.5
34	Cedar Creek, mouth	272.3	3.5	1133.5	4.2	1.2
35	Eau Claire River, mouth	277.6	5.3	1142	8.5	1.6
36	Big Rib River, mouth	278.9	1.3	1145.8	3.3	3.0
37	Wausau lower bridge	281	2.1	1153.5	7.7	3.7
38	Wausau Dam, foot	282	1	1174	20.5	20.5
39	Wausau Dam, crest	.....	.....	1180	6	.....
40	Brokaw, below	287.3	5.3	1185.7	5.7	1.1
41	Brokaw, above	.....	.....	1201.2	15.5	.....
42	Trap River, mouth of	292	4.7	1203.7	2.5	0.5
43	Pine River, mouth of	296.4	4.4	1216.3	12.6	2.9
44	Lindore Dam Merrill, below	301.8	5.4	1233.0	16.7	3.1
45	Lindore Dam Merrill, above	.....	.....	1244.4	11.4	.....
46	Upper Dam Merrill, below	304.1	2.3	1245.5	1.1	0.5
47	Upper Dam Merrill, above	.....	.....	1250.8	5.3	.....
48	Copper River, mouth	307.2	3.1	1256.7	5.9	1.9
49	Bill Cross Rapids, Sec. 18 & 14, T. 32, R. 5 E.	311.2	4.1	1274	17.3	4.2
50	Bill Cross Rapids, between Range line 5 & 6	311.6	0.4	1280	6.0	15
51	Grandfather Falls, foot T. 32, T. 33	314.4	2.8	1293.5	13.5	4.8
52	Grandfather Falls, between sec. 30 & 31	315.4	1.0	1340.5	47	47
53	Grandfather Falls, head of	316.2	0.8	1385	44.5	55.6
54	Grandmother Falls, between Sece. 3 & 10, T. 33, R. 6 E.	321.4	5.2	1401	16	3.1
55	Little Pine Creek, mouth	324.1	2.7	1410	9	3.3
56	Gilbert Station	326.4	2.3	1415.5	5.5	2.4
57	Tomahawk Dam, below	328.4	2.0	1417.0	2.5	1.2
58	Tomahawk Dam, above	.....	.....	1431	14	.....
59	Nigger Island	344.4	16.0	1454.7	23.7	1.5
60	Whirlpool Rapids, head of	346.4	2	1470.1	15.4	7.7
61	Hat Rapids	351.4	5	1482.7	12.6	2.5
62	Rhinelander Dam, below	357.4	6	1528.5	45.8	7.6
63	Rhinelander Dam, above	.....	.....	1558.5	30	.....
64	Otter Rapids, heead of	392.4	35	1570.7	12.2	0.35
65	Sec. 30, T. 41 N., R. 10 E.	402.4	10	1592.7	22	2.2
66	Sec. 6, T. 41 N., R. 10 E.	416.4	14	1644	51.3	3.6
67	Lac Vieux Desert	428.7	12.3	1650	6.0	0.5

Authority: Nos. 1-5 and 53-55 and 64-67 inclusive U. S. Engr. 6-58 Wis., and U. S. Geological Co-operative Surveys in charge of L. S. Smith, 59-64, inclusive C. B. Pride's Survey.

WISCONSIN RIVER SURVEY.[1]

In order to point out the power possibilities along the Wisconsin River, a survey was made during 1906 between Kilbourn City and Tomahawk Dam. From the data collected sheets have been prepared, showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of that survey have been published on separate sheets and may be had upon application to the Director of the Geological Survey.

GEOLOGY.

All that part of the Wisconsin River basin above Nekoosa, including over half the entire drainage, is underlain by pre-Cambrian rocks. North of Merrill this region has been coverd so deeply by drift that the rock rarely outcrops except in the river bed. These rocks, by presenting a barrier to further erosion, cause numerous rapids; in fact, all the water powers, with but a single exception,[2] are found in the pre-Cambrian area. Below Nekoosa the pre-Cambrian rocks give way to the softer Cambrian sandstone, the disintegration of which has made the bed of the river one succession of shifting sandbars, almost without interruption, to its mouth. North of Nekoosa this sandy belt rapidly narrows and, at Merrill, 90 miles above, almost entirely disappears, being replaced by the clayey loams and loamy clays. North of Tomahawk the clays are replaced again by sandy soils containing gravel and by bowlders and glacial drift.[3] In the 60 miles below the city of Tomohawk the tributaries of Wisconsin River flow mainly through a clayey-loam soil, except for a narrow strip adjacent to the main stream, where, as before stated, the sandy soil predominates.

For a distance of about seven miles in the vicinity of Kilbourn, the river flows through a narrow gorge, known as the Dalles of the Wisconsin, carved out of the Potsdam sandstone. The river suddenly narrows down from 1,400 feet to 200 feet and at one place to even 40 feet wide. At this place the river virtually runs on its edge. The profile shows a depth of 40 feet at low water at this place.

The remarkable absence of a water shed at Portage between the

[1] This survey was in charge of Leonard S. Smith. The field work was done by D. H. Dugan.

[2] Kilbourn, in the Cambrian sandstone.

[3] Weidman, Samuel, Wis. Geol. Nat. Hist. Survey, Bull. 11, pl. 1.

Fox and Wisconsin rivers has been discussed under the head of the Fox River. Beginning a few miles below Portage, the river valley is characterized by bluffs which gradually increase in height as the mouth of the river at Prairie du Chien is approached. On the south side of the valley, the bluffs often rise to a height of 300 to 350 feet above the valley, nearly vertical. The bluffs are formed by the projecting edge of the Lower Magnesian limestone, which acting as a barrier, has forced the river to flow westward until the deep trough of the Mississippi is finally found.

The Baraboo ridges consist of two lines of ridges of quartzite extending nearly east and west in the section of country west of Portage. They are four to six miles apart, about 25 miles long and unite in an abrupt headland in the bend of the Wisconsin River opposite Portage, where they end. Apparently, the bend of the river, to the east and then west, was caused by an effort to find a passage around this rock barrier.

RAINFALL AND RUN-OFF.

As the Wisconsin flows from the extreme northern to nearly the extreme southern part of the state, the rainfall on its basin, would be nearly the average of the state, viz., 32.5 inches. The distribution of the rainfall on drainage areas above Merrill, Necedah and Kilbourn is graphically shown in Plate XIX in which it will be seen that the average rainfall between 1889 and 1905 on the above areas is respectively 32.3 inches, 31.3 inches and 30.9 inches.[1]

The distribution of this rainfall in the storage, growing and replenishing periods is here shown both for the entire epoch as well as for each year of this period.

On page 115 will be found a compilation[2] of the rainfall in the valley of Wisconsin river above Merrill and above Grand Rapids, for the twelve years following 1895. This is based upon the recorded rainfall at Antigo, Crandon, North Crandon, Heafford Junction, Merrill, Koepenick, Tomahawk, Minocqua, Stevens Point, Grand Rapids and Wausau.

[1] Taken from D. W. Mead's Water Power Engineering.
[2] Compiled by A. A. Babcock.

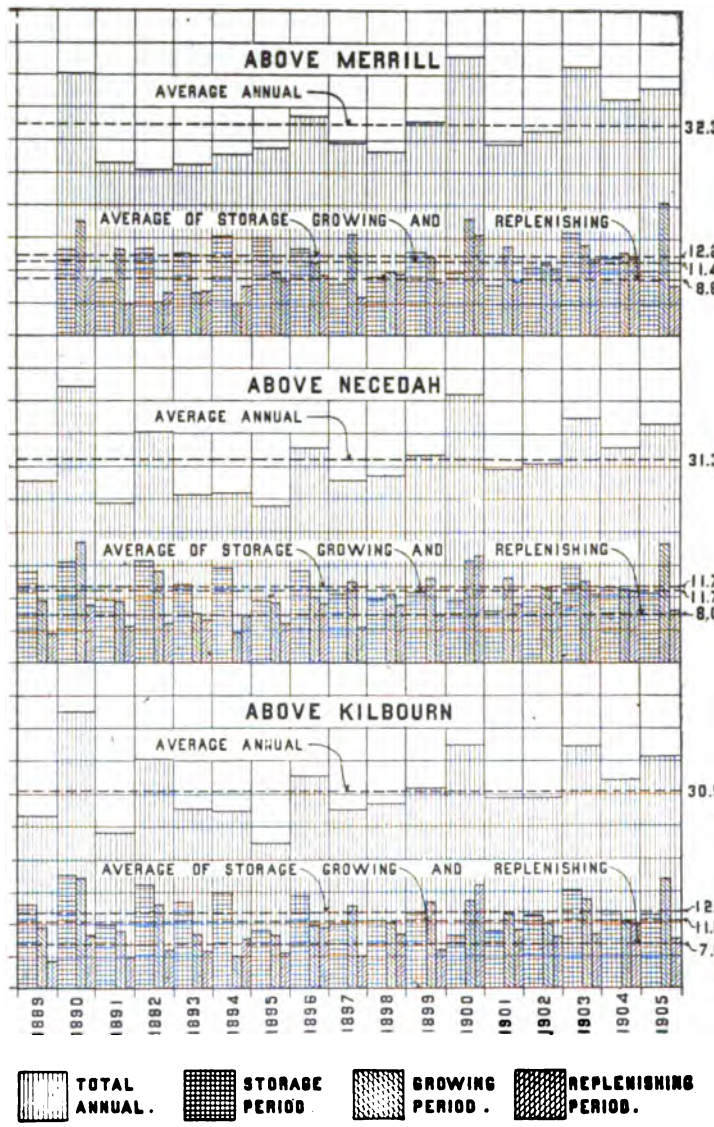

Plate XIX—Distribution of Rainfall in the Drainage area of Wisconsin River.

Average precipitation for years given, at headwaters of the Wisconsin river from observations taken at the following stations: Antigo, Crandon, North Crandon, Hartford Junction, Merrill, Kopenick, Tomahawk, Minocqua.

Year.	Jan.	Feb.	Mar.	April	May.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1896	0.97	0.40	1.07	3.36	4.80	2.60	2.64	4.56	2.20	2.89	4.08	1.23	30.80
1897	1.54	1.32	2.25	1.31	2.10	4.99	3.24	2.01	2.58	2.71	1.20	0.66	25.91
1898	0.71	1.90	2.03	1.68	2.50	3.53	3.01	1.98	2.40	3.53	1.99	0.32	25.58
1899	1.07	0.94	2.27	3.70	3.67	5.12	2.50	3.01	2.85	3.90	0.62	1.61	31.26
1900	0.64	1.17	1.35	2.67	1.55	2.14	9.55	3.75	8.20	8.22	0.88	0.68	40.89
1901	0.77	1.27	2.40	1.11	2.66	4.06	5.01	3.61	4.54	1.78	2.27	0.87	29.15
1902	0.92	1.05	1.00	2.19	4.54	3.53	3.23	2.07	2.27	1.96	3.85	1.70	28.31
1903	0.47	0.83	2.40	2.65	5.97	1.41	5.93	6.20	6.32	2.12	0.98	0.68	35.96
1904	0.46	1.22	1.56	1.95	6.06	4.68	3.22	3.43	5.88	5.28	0.26	1.94	35.94
1905	1.01	0.68	1.29	1.26	4.18	7.54	2.64	5.47	3.44	1.93	1:72	1.13	32.29
1906	1.96	0.45	2.19	1.58	4.17	5.63	2.37	4.25	2.95	2.84	3.19	1.36	32.94
1907	1.61	0.37	1.61	2.26	1.65	3.30	3.17	3.10	5.75	0.72	0.69	0.75	24.98
Grand av..	1.01	0.97	1.79	2.14	3.65	4.04	3.88	3.62	4.12	3.16	1.73	1.08	31.17

Average precipitation for years given, at headwaters of the Wisconsin river from observations taken at the following stations: Antigo, Crandon, North Crandon, Heafford Junction, Merrill, Kopenick, Tomahawk, Minocqua, Stevens Point, Grand Rapids, Wausau.

Year.	Jan.	Feb	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec	Total
1896	0.95	0.41	1.03	3.06	4.72	1.83	3.04	4.13	2.17	2.88	4.11	1.20	29.53
1897	1.40	1.36	2.21	1.11	2.07	4.92	3.18	1.70	2.50	2.98	1.31	0.56	25.30
1898	0.6[illegible]	1.80	1.60	1.70	2.49	4.01	2.67	1.33	2.47	2.82	1.94	0.29	23.77
1899	0.89	0.86	2.38	3.33	3.98	3.79	2.20	3.25	3.20	4.78	0.42	1.79	30.87
1900	0.61	1.30	1.44	2.55	1.42	2.68	8.40	4.06	8.23	7.58	1.03	0.80	41.00
1901	0.80	0.77	3.90	0.65	1.77	4.28	6.79	3.47	4.59	2.28	1.45	0.61	31.36
1902	0.88	0.87	0.87	2.48	2.74	4.30	2.14	1.51	1.89	2.13	4.24	1.13	25.18
1903	0.48	0.54	2.45	2.27	5.49	1.65	5.47	6.39	7.56	2.38	0.86	0.59	36.13
1904	0.40	1.34	1.62	2.08	5.86	5.78	3.54	4.36	7.05	5.43	0.29	2.45	40.20
1905	1.21	0.65	1.38	1.15	3.83	7.32	2.45	5.65	3.86	2.02	1.75	1.06	32.33
1906	1.85	0.54	2.00	1.49	4.76	5.07	2.39	4.01	2.47	2.45	2.60	1.10	31.63
1907	1.24	0.54	1.45	2.26	1.23	2.61	2.81	2.61	6.65	0.73	0.52	0.52	23.16
Grand total	0.95	0.92	1.86	2.01	3.36	4.02	3.76	3.69	4.39	3.20	1.71	1.01	30.87

Gaging Station at Muscoda, Wis.

This station was established December 20, 1902. It is situated three-fourths of a mile north of Muscoda on the toll highway bridge.

The gage is a horizontal wire with a scale board graduated to feet and tenths and fastened to the top of the bridge. The initial point for soundings is on the left bank, at the end of the drawbridge. The channel is straight for 1,500 feet above and 1,000 feet below the station, and has a width of about 800 feet, broken by 13 piers. The right bank is low and liable to overflow. The water is confined to the bridge opening. The left bank is high and rocky. The bed of the stream is rocky, with spots of gravel, and is liable to shift. The flow is moderately rapid. The gage was read twice a day by Charles H. Lovell, the bridge tender, during 1903.

Bench mark No. 1, elevation 684 feet above sea level, bolt in south end of east guard rail at south end of bridge. Its elevation has been determined by United States Geological Survey levels. Bench mark No. 2, elevation 681.17 feet, nail in root on north side of 20-inch black oak tree standing about 40 paces south by east from the south end of the drawbridge. Bench mark No. 3, elevation 680.95 feet, a projecting point on a sandstone rock on the east end of south abutment, near the supporting wheel at end of drawbridge. On the vertical face of the stone is an arrow pointing upward to this point. The stone is also marked B. M. Bench mark No. 4, elevation 684.25 feet. a point marked X on foundation stone at the southeast corner of Lampi's brewery. The 15-foot mark has an elevation of 668.62 feet. There is a line cut on the girder opposite the 10-foot mark. This station was discontinued December 31, 1903.

Discharge measurements of Wisconsin River at Muscoda, Wis., in 1903.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Second-feet.*
January 10	L. R. Stockman	14.85	[1]4,812
January 28	do	14.65	[1]4,649
March 26	do	19.70	38,182
April 21	do	16.25	14,163
July 2	A. C. Lootz	15.20	5,870
October 9	L. R. Stockman	18.33	18,954

[1]Partly frozen.

Mean daily gage height, in feet, of Wisconsin River, at Muscoda, Wis., for 1903.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
20	15.00	23	15.05	26	14.80	29	14.55
21	15.05	24	15.05	27	14.70	30	14.75
22	15.00	25	14.85	28	14.55	31	14.75

Mean daily gage height, in feet, of Wisconsin River at Muscoda, Wis., for 1903.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	14.75	14.90	15.85	18.05	15.97	18.68	15.23	15.40	16.78	18.05	16.52	16.33
2	14.85	14.90	15.80	17.50	16.07	18.95	15.18	15.43	16.68	17.85	16.42	16.26
3	14.90	14.95	15.70	17.25	15.98	19.28	15.25	15.30	16.65	17.75	16.40	16.25
4	14.90	15.00	15.60	17.02	16.35	19.55	15.18	15.38	16.83	17.32	16.32	16.22
5	14.90	14.90	15.50	16.75	17.15	19.78	15.20	15.53	16.85	17.30	16.32	16.22
6	14.90	14.90	15.40	16.70	17.70	19.52	17.00	15.68	16.73	17.32	16.30	16.20
7	14.80	14.85	15.55	16.60	17.95	18.50	17.90	15.55	16.53	17.47	16.25	16.35
8	14.70	14.85	15.90	16.50	18.07	17.75	18.40	15.58	16.50	17.87	16.17	16.35
9	14.65	15.00	15.70	16.32	18.22	17.42	18.60	16.05	16.63	18.40	16.10	16.40
10	14.75	15.00	15.40	16.22	18.40	17.07	18.90	16.75	16.85	18.60	16.10	16.38
11	14.65	15.05	15.20	16.20	18.40	16.85	19.10	17.33	16.98	18.60	16.20	16.30
12	14.60	15.25	15.00	16.22	18.20	16.65	19.08	17.43	17.12	18.65	16.20	16.32
13	14.65	15.20	15.05	16.30	17.80	16.47	18.35	17.28	17.48	18.85	16.12	16.32
14	14.70	15.15	15.55	16.22	17.50	16.22	17.63	17.15	17.83	18.90	16.10	.....
15	14.65	15.05	15.75	16.12	17.45	16.15	17.30	17.23	17.75	19.00	16.10	16.15
16	14.75	15.00	16.30	16.00	17.50	16.05	16.95	17.47	17.83	18.72	16.05	16.15
17	14.75	14.85	16.50	16.00	17.90	15.87	16.87	17.47	18.38	18.35	16.10	16.25
18	14.70	14.70	16.65	16.10	18.35	15.82	17.45	17.37	18.90	18.05	16.15	16.28
19	14.75	14.70	16.95	16.20	18.25	15.65	16.92	17.13	19.30	17.90	16.10	16.49
20	14.80	14.65	17.45	16.30	18.40	15.65	16.65	17.05	19.80	17.75	16.32	15.62
21	14.70	14.70	17.85	16.35	18.20	15.73	16.45	16.95	20.80	17.47	17.00	15.62
22	14.75	14.65	17.93	16.30	18.00	15.63	16.25	16.70	22.33	17.37	17.05	15.72
23	14.70	14.70	18.05	16.12	17.45	15.53	16.17	16.53	22.70	17.27	17.25	15.75
24	14.80	14.75	18.35	16.00	17.30	15.45	16.05	16.30	22.43	17.17	17.30	15.78
25	14.70	14.75	18.90	15.90	17.45	15.40	15.85	16.23	22.50	17.00	17.27	15.72
26	14.75	14.75	19.72	15.78	17.60	15.43	15.65	16.23	21.38	16.87	17.12	15.65
27	14.85	14.95	20.50	15.70	17.75	15.30	15.58	16.43	20.70	16.72	16.47	16.40
28	14.85	15.90	20.37	15.62	17.95	15.13	15.60	16.65	19.95	16.67	16.40	16.40
29	14.95	.....	19.80	15.67	18.20	15.10	15.58	17.08	19.10	16.60	16.33	16.40
30	14.80	.....	19.27	15.87	18.25	15.23	15.48	17.08	18.35	16.55	16.30	16.40
31	14.90	....	18.65	.....	18.40	.....	15.45	16.98	.....	16.55	.....	16.40

Daily gage height of Wisconsin River at Kilbourn for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.5	.....	8.8	5.2	6.1	5.8	.....	.....	1.9	1.8	5.9
2	.....	2.5	3.1	7.6	5.2	5.7	6.2	.....	2.7	1.8	1.9	5.3
3	.....	.....	3.5	8.5	5.0	5.6	.....	.....	2.0	1.5	2.0	4.4
4	.....	.....	.....	9.7	5.0	5.3	.....	.....	2.1	1.3	1.9	4.3
5	.....	.....	.....	10.7	4.7	5.1	.....	.....	2.2	1.0	1.9	4.3
6	.....	.....	.....	11.2	5.7	4.7	.....	.....	2.1	0.7	2.0	4.3
7	.....	.....	.....	11.8	4.7	4.8	.....	.....	2.3	0.5	2.0	4.3
8	.....	.....	.....	12.4	4.7	5.1	.....	.....	2.1	0.4	1.6	3.8
9	.....	.....	.....	12.8	4.8	5.5	.....	.....	2.2	0.3	1.6	3.8
10	.....	.....	.....	13.4	4.5	5.9	.....	.....	2.1	0.2	1.5	3.8
11	.....	.....	.....	13.5	4.4	6.4	.....	.....	1.7	0.3	1.5	3.7
12	.....	.....	.....	13.5	.....	6.4	.....	.....	1.5	0.3	1.4	3.7
13	.....	.....	.....	13.7	4.0	6.0	.....	.....	1.0	0.4	1.3	3.2
14	.....	.....	.....	13.6	3.8	.....	.....	.....	0.5	.....	1.3	2.8
15	2.2	.....	.....	13.2	4.0	5.4	.....	.....	0.9	.....	1.2	2.8
16	2.1	.....	.....	13.2	5.0	4.0	.....	.....	0.8	.....	1.1	2.8
17	2.6	.....	.....	13.3	5.1	3.6	.....	.....	1.0	.....	1.0	2.3
18	2.7	.....	.....	13.3	4.9	3.2	.....	.....	1.0	.....	1.0	1.6
19	2.4	.....	2.1	12.6	4.5	2.5	.....	0.7	1.1	.....	1.4	1.8
20	2.4	.....	2.1	11.6	.....	2.0	.....	0.6	1.4	.....	1.9	2.0
21	2.2	.....	2.5	10.6	3.8	2.4	.....	0.7	1.3	.....	2.5	1.7
22	2.4	.....	2.2	9.6	3.6	2.6	.....	1.0	1.1	.....	2.7	2.0
23	2.3	.....	2.3	9.4	3.5	3.3	.....	1.1	1.2	.....	.....	2.2
24	2.8	.....	.....	9.0	3.2	4.0	.....	1.3	1.5	1.2	.....	2.5
25	2.8	.....	.....	8.3	2.8	4.3	.....	1.4	1.6	1.5	.....	1.9
26	2.8	.....	3.5	7.4	3.00	5.0	.....	2.3	1.6	1.5	.....	2.1
27	2.7	.....	4.8	6.9	3.1	5.0	.....	2.7	1.8	1.6	3.1	2.0
28	2.7	.....	5.7	6.3	3.9	5.0	.....	3.3	1.8	1.5	3.5	2.0
29	2.6	.....	7.6	5.7	4.3	4.8	.....	4.0	1.8	1.7	4.0	1.7
30	2.7	.....	7.8	5.3	5.3	5.3	.....	4.0	1.8	1.8	5.2	1.5
31	2.5	.....	8.2	.....	.....	.....	.....	3.5	.....	1.7	.....	1.9

Kilbourn, Wisconsin.—This station is a staff gage located on the lower side of the old mill and near the new dam now being constructed. The elevation of the zero of this gage is 811.17 above the sea. This gage was established many years ago but was not read regularly until the beginning of 1906. The construction of the dam will make it necessary to change the location of this gage to a point farther down stream. In fact two or more such gages have already been established and are being read in preparation of such change. The zero of gage is reference by levels to several bench marks in the vicinity.

*Daily gage height of Wisconsin River at Kilbourn for 1907.**

Day.	Jan.	Feb.	Mar.	Apr.	Mar.	June.	Ju y	Aug.	Sept	Oct.	Nov.	Dec.
1	1.7	4.1	2.4	12.8	5.5	3.5	1.3	1.0	0.9	2.8	0.1	0.2
2	1.9	4.1	2.5	12.8	5.4	3.2	1.4	1.1	0.7	2.3	0.0	0.1
3	.....	4.0	2.5	12.9	5.3	3.0	1.8	0.9	0.7	2.3	0.2	0.0
4	1.9	3.9	2.6	12.1	5.0	2.9	2.8	0.6	1.2	1.9	0.3	0.6
5	1.9	3.7	2.3	10.8	5.0	3.0	3.4	0.6	0.6	1.6	0.3	0.1
6	.....	4.1	2.3	9.9	4.9	2.5	3.7	0.5	0.4	1.5	0.3	0.1
7	1.5	4.0	2.1	9.2	4.9	2.4	3.9	0.4	0.4	1.4	0.2	0.6
8	1.5	3.6	2.1	9.0	4.7	2.4	4.4	0.4	0.3	1.3	0.0	0.6
9	2.6	3.5	2.0	8.7	4.2	2.3	4.7	0.4	0.2	1.1	0.1	0.7
10	2.5	3.3	2.0	8.1	4.2	2.2	3.7	0.3	—0.2	1.0	0.2	0.4
11	2.5	3.3	2.0	7.4	4.0	2.3	3.5	0.3	0.4	0.4	0.2	0.3
12	2.5	3.2	2.3	6.9	3.7	2.3	3.3	0.1	0.0	0.8	0.0	0.2
13	2.5	3.5	2.9	6.6	3.5	2.3	3.1	—0.1	0.0	0.9	0.3	0.4
14	2.7	3.3	2.9	6.6	3.7	2.3	2.6	0.2	0.1	0.8	—0.1	0.5
15	3.0	3.2	3.1	6.8	3.8	2.3	2.1	0.2	0.0	0.8	0.1	0.4
16	3.7	3.1	3.3	6.7	3.4	2.1	2.1	0.3	—0.1	1.0	0.2	0.3
17	3.0	3.3	3.1	6.5	3.8	1.9	1.7	0.1	0.2	0.3	0.0	0.0
18	3.0	3.5	2.8	6.0	4.5	1.9	1.7	0.8	0.6	0.3	—0.2	0.5
19	3.0	3.3	2.8	5.8	5.3	1.9	1.4	0.5	0.5	0.3	0.0	0.5
20	3.5	3.7	2.5	5.0	5.4	1.4	1.8	0.2	0.8	0.4	0.0	0.1
21	4.0	3.3	2.6	4.8	5.0	1.3	2.3	0.3	1.0	0.5	—0.2	0.4
22	3.9	3.2	2.6	4.7	5.1	1.3	2.7	0.8	3.4	0.2	0.0	0.3
23	4.3	3.0	3.2	4.7	4.5	.....	2.8	0.3	5.8	0.4	0.0	0.4
24	4.3	3.0	3.6	4.4	4.3	1.5	3.3	0.8	7.0	0.2	0.2	0.6
25	4.3	3.0	4.1	4.8	4.2	0.9	2.8	0.8	7.2	0.2	0.3	0.4
26	4.5	2.7	5.3	4.9	4.3	1.9	2.5	0.8	6.0	0.1	0.2	0.4
27	4.5	2.8	6.7	5.1	4.2	1.9	2.5	1.3	4.6	0.1	0.3	—0.3
28	4.3	2.6	8.3	5.2	4.2	1.7	2.4	1.3	4.1	0.1	0.3	.....
29	4.0	.....	10.1	5.2	4.0	1.7	2.1	1.2	3.4	0.2	0.2	.....
30	4.6	.....	11.9	5.5	4.0	1.8	2.0	1.2	2.8	0.5	0.0	.....
31	4.1	.....	13.0	.....	4.0	.....	2.0	1.2	.....	0.3	.....	.....

* Note—All gage heights at Kilbourn are furnished by the Southern Wisconsin Power Company.

The following discharge measurements have been made by Mr. V. H. Reineking under the direction of Mr. D. W. Mead. The gaging section was about 500 feet above the City Water Works in Kilbourn.

Gage height.	Cu. ft. per Sec.
0.7	4,200
0.7	4,300
6.35	16,700
6.9	18,100
7.35	19,300
8.25	20,300
8.9	23,500
10.6	29,500
11.5	32,200
13.3	39,500

The above measurements give a good rating curve for open river conditions up to a gage height of 15 feet.

The following rating table has been prepared from the rating curve furnished by D. W. Mead.

Rating table for Wisconsin River at Kilbourn, Wis. (Open Conditions).

Gage height.	Discharge.	Gage Height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
0.00	2,900	2.40	7,810	4.80	13,190	7.20	19,060
0.10	3,100	2.50	8,025	4.90	13,420	7.30	19,315
0.20	3,300	2.60	8,240	5.00	13,650	7.40	19,570
0.30	3,500	2.70	8,455	5.10	13,890	7.50	19,825
0.40	3,700	2.80	8,670	5.20	14,130	7.60	20,080
0.50	3,900	2.90	8,885	5.30	14,370	7.70	20,335
0.60	4,100	3.00	9,100	5.40	14,610	7.80	20,590
0.70	4,300	3.10	9,325	5.50	14,850	7.90	20,845
0.80	4,500	3.20	9,550	5.60	15,090	8.00	21,100
0.90	4,700	3.30	9,775	5.70	15,330	8.50	22,450
1.00	4,900	3.40	10,000	5.80	15,570	9.00	23,900
1.10	5,105	3.50	10,225	5.90	15,810	9.50	25,300
1.20	5,310	3.60	10,450	6.00	16,050	10.20	26,900
1.30	5,515	3.70	10,675	6.10	16,300	10.25	28,800
1.40	5,720	3.80	10,900	6.20	16,550	11.30	30,300
1.50	5,925	3.90	11,125	6.30	16,800	11.35	32,200
1.60	6,130	4.00	11,350	6.40	17,050	12.40	34,100
1.70	6,335	4.10	11,580	6.50	17,300	12.45	36,200
1.80	6,540	4.20	11,810	6.60	17,550	13.50	38,400
1.90	6,745	4.30	12,040	6.70	17,800	13.55	41,000
2.00	6,950	4.40	12,270	6.80	18,050	14.00	43,700
2.10	7,165	4.50	12,500	6.90	18,300	14.65	46,800
2.20	7,380	4.60	12,730	7.00	18,550	15.70	50,400
2.30	7,595	4.70	12,960	7.10	18,805		

Discharge measurements of Wisconsin River at Kilbourn, Wis.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height. Water sur.	Discharge	Av. th. of ice.	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.	*Feet.*	*Feet.*
1908. March 3*	G. A. Gray	252	1,730	1.75	1.5	3,061	1.1	No.

* Note—Velocities were observed at 0.2 and 0.8 of the depth.

The United States Geological Survey has maintained regular gaging stations at Necedah and Merrill since November, 1902. As the rainfall during 1904 was very close to the average rainfall for the past thirty years, the run-off data for this year are especially valuable.

Rainfall records for this drainage area are given elsewhere in this report. The following tables give the run-off data:

Discharge measurements of Wisconsin River near Necedah, Wis., in 1902, 1903, 1904, 1905, 1908.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
1902.						
December 2	L. R. Stockman	.....	.....	.....	4.90	3,875
December 23	..... do	.....	.....	.....	5.40	3.534
1903.						
January 13[1]	..... do	280	2,617	1.18	5.65	2,840
February 5[1]	..... do	284	2,360	1.26	5.80	2,585
March 5[1]	..... do	284	2,411	1.09	5.80	2,422
March 26	Johnson and Stockman	.....	5,405	3.94	11.05	21,280
April 2	L. R. Stockman	220	4,206	9.42	7.55	10,190
April 28	..... do	309	3,860	1.84	6.50	7,123
June 12	..... do	281	3,282	1.79	6.00	5,898
July 7	..... do	316	4,708	4.43	10.50	20,860
August 19	..... do	302	2,832	2.46	6.20	6,962
September 4	..... do	276	2,463	2.05	5.30	5,047
October 12	..... do	314	3,871	3,23	9.43	12,500
1904.						
January 12[1]	E. Johnson, jr	286	2,031	1.33	4.60	3,600
May 11	..... do	317	4,665	3.65	9.60	17,110
May 23	Johnson and Hanna	314	3,717	2.67	7.05	9,921
July 16	E. Johnson, jr.	294	3,525	1.66	5.80	5,845
September 21	..... do	294	1,823	2.08	4.92	3,800
October 14	F. W. Hanna	449	6,216	5.71	13.35	[2]34,420
1905.						
April 4	S. K. Clapp	.....	5,777	5.07	12,33	29,290
May 25	..... do	317	4,437	3.23	7.65	13,350
June 12	M. L. Brennon	437	6,017	4.99	12.9	30,050
August 9	..... do	314	3,846	2.4	6.85	9,268

Note.—Width is the actual width of water surface, not including piers. Area of section is the total area of the measured section, including both moving and still water.

[1] Frozen.

[2] Add to this discharge 3,000 second-feet overflow.

Discharge measurements under ice of Wisconsin River near Necedah, Wis.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height. Water sur.	Discharge	Av. th. of ice.	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft	Feet.	Feet.
1908.								
January 29	G. A. Gray	276	1,550	1.27	5.15	1,963	1.0	None.
February 19	..... do	273	1,399	1.64	5.7	2,281	1.1	.2

Record of ice thickness, 1907–8.

1908.		Feet.
Dec. 22	River closed.	
Dec. 24	Average thickness of ice	0.5
Dec. 31	do do	0.6
Jan. 7	do do	0.7
Jan. 14	do do	0.7
Jan. 21	do do	0.8
Jan. 28	do do	1.1
Feb. 4	do do	1.0
Feb. 11	do do	1.2
Feb. 18	do do	0.9
Feb. 25	do do	1.1
Mch. 3	do do	0.9
Mch. 10	do do	.08
Mch. 10	Ice went out.	

Mean daily gage height in feet, of Wisconsin River near Necedah, Wis., December 2, 1902, to December 31, 1907.

Day.	1902.	1903.											
	Dec	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.90	5.75	5.75	7.70	6.65	10.55	4.70	4.80	5.20	7.10	5.70	5.60
2	4.90	5.90	5.70	5.60	7.55	8.30	9.85	4.60	4.95	5.50	6.60	5.55	6.20
3	4.95	5.80	5.90	5.85	7.35	9.35	8.85	7.70	4.75	5.40	6.80	5.70	6.90
4	5.10	5.75	5.80	5.80	7.50	9.75	8.15	8.90	4.80	5.30	6.80	5.75	7.10
5	4.85	5.60	5.75	5.75	7.40	9.95	7.60	10.10	4.85	5.30	7.05	5.55	6.80
6	4.75	5.70	5.90	5.80	7.25	10.15	7.40	10.00	5.65	5.40	8.30	5.45	6.80
7	4.70	5.65	5.80	5.90	7.15	10.05	7.15	10.60	6.65	5.60	9.05	5.30	6.60
8	4.30	5.45	5.70	5.50	7.20	9.70	6.85	10.60	7.75	6.10	8.95	5.50	6.70
9	4.85	5.60	5.60	5.50	7.10	9.30	6.65	9.70	8.00	6.10	9.15	5.35	6.50
10	5.25	5.50	5.80	6.25	7.25	8.80	6.55	8.40	7.70	6.80	9.80	5.30	6.40
11	5.20	5.45	5.75	6.40	7.05	8.25	6.20	7.80	7.50	7.30	9.80	5.25	6.30
12	5.40	5.50	5.65	7.05	6.90	8.15	6.00	7.50	7.20	7.30	9.35	5.30	6.00
13	5.25	5.65	5.90	7.65	6.80	8.45	6.15	7.10	6.90	7.20	8.90	5.30	[1]4.10
14	5.30	5.75	5.80	6.75	6.75	9.05	5.85	6.70	6.70	8.60	8.30	5.30	4.40
15	5.35	5.45	5.75	7.30	6.80	9.80	5.70	6.55	6.70	10.90	7.90	5.35	4.50
16	5.65	5.80	5.65	7.75	6.95	10.10	5.45	6.25	6.40	12.50	7.65	5.25	4.40
17	5.65	5.65	5.65	8.35	7.10	9.90	5.35	6.00	6.20	13.40	7.55	5.35	4.00
18	5.30	5.55	5.55	8.70	7.25	9.35	5.60	6.10	6.40	14.60	7.25	4.90	4.40
19	5.50	5.45	5.75	8.85	7.10	8.70	5.45	5.90	6.10	14.60	6.95	4.90	4.30
20	5.45	5.75	5.70	10.00	6.90	8.30	5.25	6.00	5.70	14.60	7.00	5.00	5.00
21	5.30	5.65	5.70	11.40	6.50	7.95	5.15	5.90	5.90	13.80	6.95	5.10	4.80
22	5.30	5.55	5.65	12.70	6.55	7.90	4.90	5.60	5.40	12.70	6.55	5.05	4.90
23	5.40	5.85	5.55	13.55	6.30	7.75	5.20	5.40	5.10	11.40	6.40	4.95	4.90
24	5.60	5.80	5.70	12.85	6.20	7.45	4.95	5.20	5.10	10.60	6.40	5.20	4.80
25	6.40	5.80	5.65	11.80	6.05	7.35	4.70	5.30	5.40	9.90	6.30	5.20	4.70
26	6.30	5.65	5.65	10.90	6.10	7.00	4.80	5.30	5.20	8.70	6.10	5.05	4.70
27	6.60	5.85	5.70	10.05	6.35	8.00	4.75	5.00	5.30	8.15	6.05	5.00	4.90
28	6.15	5.80	5.85	9.35	6.50	8.70	4.80	5.10	5.30	7.95	5.95	5.15	4.80
29	6.05	5.70	.....	8.95	6.85	9.55	4.70	5.00	5.20	7.65	6.00	5.00	4.90
30	6.20	5.80	.....	8.50	6.60	10.55	4.85	4.90	5.00	7.55	5.80	5.40	4.90
31	6.00	5.80	.....	8.00	.....	11.00	.....	4.80	5.00	.....	5.70	.....	4.90

[1] River frozen December 13 to 31.

Rating table for Wisconsin River near Necedah, Wis., from March 10 to July 5, 1903.[1]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Second-feet.*
4.6	3,400	5.9	5,680	7.2	9,160	8.8	14,160
4.7	3,540	6.0	5,900	7.3	9,460	9.0	14,800
4.8	3,690	6.1	6,130	7.4	9,760	9.2	15,440
4.9	3,840	6.2	6,370	7.5	10,060	9.4	16,080
5.0	4,000	6.3	6,620	7.6	10,360	9.6	16,720
5.1	4,160	6.4	6,880	7.7	10,670	9.8	17,360
5.2	4,320	6.5	7,150	7.8	10,980	10.0	18,000
5.3	4,490	6.6	7,430	7.9	11,290	10.5	19,600
5.4	4,670	6.7	7,710	8.0	11,600	11.0	21,200
5.5	4,860	6.8	8,000	8.2	12,240	11.5	22,920
5.6	5,060	6.9	8,290	8.4	12,880	12.0	24,670
5.7	5,260	7.0	8,580	8.6	13,520	13.0	28,360
5.8	5,470	7.1	8,870				

[1] Flood in July changed channel.

Rating table for Wisconsin River near Necedah, Wis., from July 6 to December 12, 1903.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec-feet*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Second-feet.*
4.8	4,200	6.1	6,780	7.4	10,440	9.2	16,460
4.9	4,350	6.2	6,970	7.5	10,760	9.4	17,160
5.0	4,510	6.3	7,220	7.6	11,080	9.6	17,840
5.1	4,680	6.4	7,480	7.7	11,410	9.8	18,520
5.2	4,860	6.5	7,750	7.8	11,740	10.0	19,200
5.3	5,040	6.6	8,030	7.9	12,070	10.5	20,900
5.4	5,230	6.7	8,320	8.0	12,400	11.0	22,600
5.5	5,430	6.8	8,620	8.2	13,080	11.5	24,300
5.6	5,630	6.9	8,920	8.4	13,760	12.0	26,000
5.7	5,840	7.0	9,220	8.6	14,440	12.5	27,700
5.8	6,050	7.1	9,520	8.8	15,120	13.0	29,400
5.9	6,270	7.2	9,820	9.0	15,800	14.0	32,800
6.0	6,500	7.3	10,130				

Rating table for Wisconsin near Necedah, Wis., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Second-feet.*
4.0	1,900	5.4	4,880	6.7	8,500	9.0	15,400
4.1	2,000	5.5	5,130	6.8	8,800	9.2	16,000
4.2	2,200	5.6	5,380	6.9	9,100	9.4	16,600
4.3	2,400	5.7	5,640	7.0	9,400	9.6	17,200
4.4	2,600	5.8	5,900	7.2	10,000	9.8	17,800
4.5	2,810	5.9	6,170	7.4	10,600	10.0	18,400
4.6	3,020	6.0	6,440	7.6	11,200	10.5	19,900
4.7	3,240	6.1	6,720	7.8	11,800	11.0	21,400
4.8	3,460	6.2	7,010	8.0	12,400	11.5	23,610
4.9	3,690	6.3	7,300	8.2	13,000	12.0	25,920
5.0	3,930	6.4	7,600	8.4	13,600	12.5	28,230
5.1	4,150	6.5	7,900	8.6	14,200	13.0	30,750
5.2	4,390	6.6	8,200	8.8	14,800	13.5	38,450
5.3	4,630						

Rating table for Wisconsin River near Necedah Wis., from January 1, 1905, to December 31, 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Second-feet.*
4.00	1,800	5.50	5,130	7.00	9,400	9.80	17,800
4.10	2,000	5.60	5,380	7.20	10,000	10.00	18,400
4.20	2,200	5.70	5,640	7.40	10,600	10.50	19,900
4.30	2,400	5.80	5,900	7.60	11,200	11.00	21,400
4.40	2,600	5.90	6,170	7.80	11,800	11.50	23,610
4.50	2,810	6.00	6,440	8.00	12,400	12.00	25,860
4.60	3,020	6.10	6,720	8.20	13,000	12.50	28,230
4.70	3,240	6.20	7,010	8.40	13,600	13.00	30,750
4.80	3,460	6.30	7,300	8.60	14,200	13.50	38,450
4.90	3,690	6.40	7,600	8.80	14,800	14.00	46,200
5.00	3,920	6.50	7,900	9.00	15,400	15.00	61,800
5.10	4,150	6.60	8,200	9.20	16,000	16.00	77,500
5.20	4,390	6.70	8,500	9.40	16,600	17.00	93,300
5.30	4,630	6.80	8,800	9.60	17,200	18.00	109,200
5.40	4,880	6.90	9,100				

The last table is applicable only for open-channel conditions. It is based on 23 discharge measurements made during 1902-1905. It is well defined between gage heights 4.5 feet and 10.5 feet. The table has been extended beyond these limits. From gage height 6.3 feet to 11 feet the rating curve is a tangent, the difference being 300 per tenth. Above 11 feet the bank overflows, which causes the discharge to increase at a greater rate per foot.

Estimated monthly discharge of Wisconsin River near Necedah, Wis., 1903 to 1906.

[Drainage area, 5,800 square miles.]

Date.	Discharge.			Run-off.		Rainfall.[1]
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
1903.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*
January	.....	.....	[2]2,600	0.45	0.52	0.36
February	.....	.....	[2]2,550	.44	.46	.91
March[3]	30,450	.....	11,859	2.04	2.35	2.33
April	10,670	6,015	8,322	1.43	1.60	4.06
May	21,200	7,570	14,492	2.50	2.88	6.23
June	19,760	3,540	6,897	1.19	1.33	1.26
July	21,240	3,400	9,022	1.56	1.80	6.11
August	12,400	4,125	6,648	1.15	1.33	6.26
September	34,840	4,860	15,832	2.73	3.05	5.86
October	18,520	5,840	10,586	1.83	2.11	2.11
November	5,945	4,350	5,007	.86	.96	1.09
December 1-12[4]	9,520	[5]5,630	[5]7,798	[5]1.34	[5].60	.88
1904.						
January	.....	.....	.....	.....	.....	.33
February	.....	.....	.....	.....	.....	1.20
March	.....	.....	.....	.....	.....	1.49
April	21,100	7,300	12,830	2.21	2.47	2.01
May	28,720	9,400	15,250	2.63	3.03	6.20
June	22,280	5,640	11,350	1.96	2.19	4.81
July	9,700	2,810	5,926	1.02	1.18	3.28
August	6,170	2,400	3,845	.663	.764	3.21
September	10,600	2,400	5,227	.901	1.01	4.53
October	33,830	6,170	13,596	2.34	2.70	5.70
November	9,700	3,460	5,698	.982	1.10	.25
December	.....	.....	.....	.....	.....	1.86

[1] Rainfall for 1903 is the average of the recorded precipitation at the following stations: Antigo, Koepenick, Stevens Point, Wausau, Amherst, Grand Rapids, and Medford. That for 1904 includes the same stations, except Medford and adding Minocqua and Prentice.

[2] Estimated.

[3] March 1 to 9, inclusive, estimated.

[4] River frozen December 13 to 31.

[5] Twelve-day period.

Estimated monthly discharge of Wisconsin River near Necedah, Wis., for 1905 to 1906—Continued.

Date.	Discharge.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
	Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*
1905.[2]						
March 21-30	25,500	3,920	9,037	1.56	1.80	1.29
April	35,370	6,170	15,790	2.72	3.03	1.76
May	17,800	6,305	11,060	1.91	2.20	4.18
June	93,300	7,300	23,320	4.02	4.48	7.54
July	15,700	4,150	8,711	1.50	1.73	2.64
August	9,700	3,920	6,099	1.05	1.21	5.47
September	13,600	4,630	7,419	1.28	1.42	3.44
October	9,400	3,240	5,748	.991	1.14	1.93
November	5,900	3,460	4,667	.805	0.90	1.72
December	14,800	4,150	8,838	1.53	1.76	1.13
The year	.....	.....	.....	.....	.....	32.29
1906.						
April	35,400	12,100	22,600	3.90	4.35	1.58
May	14,600	7,010	10,500	1.81	2.09	4.17
June	14,600	6,170	10,800	1.86	2.08	5.63
July	13,000	2,810	6,570	1.13	1.30	2.37
August	12,100	3,240	5,240	.903	1.04	4.25
September	8,800	3,690	5,140	.886	.99	2.95
October	9,700	2,600	4,840	.834	.96	2.84
November	15,100	4,150	6,760	1.17	1.30	3.19
December 1-19[1]	13,900	6,040	8,160	1.41	1.00	1.36
1907.						
January	.....	.....	.....	.....	.....	1.61
February	.....	.....	.....	.....	.....	0.37
March, (a)	38,450	7,300	13,000	2.24	2.58	1.61
April	35,370	10,000	16,075	2.77	2.98	2.26
May	13,600	9,100	10,900	1.88	2.16	1.65
June	8,500	5,130	6,440	1.11	1.24	3.30
July	10,900	3,575	6,200	1.07	1.23	3.17
August	4,150	2,200	3,240	0.55	0.63	3.10
September	17,800	1,800	4,270	0.73	0.81	5.75
October	7,300	3,000	4,390	0.75	0.86	0.79
November	5,130	2,400	3,025	0.52	0.58	0.69
December, (b)	5,900	1,800	3,025	0.52	0.60	0.75
The year	.....	.....	.....	.....	.....	24.98

[1] Discharge values December 17 to 19 corrected for ice conditions.
[2] No estimate for ice period.
(a) 13-31 only.
(b) 1-26 only.
Note.—Values for 1906 good.

Discharge measurements of Wisconsin River at Merrill, Wis., in 1902, 1903, 1904, 1905, 1906 and 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second feet.*
1902.						
November 17	L. R. Stockman	.....	.....	.....	7.6	9,015
December 10	do	.....	.....	.....	3.8	1,394
1903.						
January 20[1]	do	310	718	1.91	4.05	1,376
February 16[1]	do	310	669	1.86	3.70	1,250
March 20	do	344	2,639	3.78	8.90	9,995
May 17[2]	do	332	2,232	3.54	6.85	7,893
June 17[2]	do	308	1,269	1.78	4.72	2,258
July 13	do	305	1,424	2.10	5.70	2,993
August 22[2]	do	283	1,115	2.36	5.00	2,638
September 11	E. C. Murphy	343	1,759	3.19	6.66	5,614
October 24	L. R. Stockman	334	1,594	2.61	6.08	4,159
1904.						
May 12[3]	E. Johnson, Jr.	334	2,220	3.71	7.85	8,242
June 5	do	334	2,286	4.19	8.25	9,587
July 15[2]	do	334	1,366	1.98	5.30	3,107
September 21	do	312	1,210	1.91	5.01	2,312
October 14	F. W. Hanna	327	2,333	4.42	8.25	10,323
November 30[1]	E. Johnson, Jr.	306	1,237	1.85	4.97	2,294
1905.						
April 10	S. K. Clapp	334	2,189	3.84	7.3	8,396
May 26	do	324	1,679	2.69	6.25	4,519
June 10	M. S. Brennan	334	2,334	4.06	8.17	9,478
July 10	do	332	1,596	2.73	6.49	4,357
1906.						
January 24[1]	do	331	1,090	1.80	5.92	1,980
April 23[2]	do	334	2,300	4.34	8.26	10,000
1907.						
April 4	A. H. Horton	328	2,417	4.93	8.47	11,215
June 13	G. A. Gray	324	1,348	2.26	5.63	3,084
July 12	do	316	1,175	2.07	5.33	2,461
August 14	do	292	924	1.68	4.62	1,573
September 17	do	293	1,021	1.82	5.00	1,876

[1] Partly frozen.
[2] Affected by log jam.
[3] Partly frozen: discharge about 50 per cent of open channel.
[4] Logs running.

Mean daily gage height, in feet, of Wisconsin River at Merrill, Wis., November 16, 1902, to December 31, 1907.

Day.	1902.		1903.											
	Nov.	Dec	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	3.65	3.80	3.70	6.75	6.65	.....	7.05	4.30	.....	6.50	5.85	5.10
2	.....	.....	3.70	3.80	3.70	6.70	8.30	.....	7.65	4.30	5.50	5.90	5.60	5.10
3	.....	.....	3.85	3.85	3.80	6.55	.....	.....	7.65	4.90	5.70	6.90	5.30	5.25
3	.....	.....	3.80	3.80	3.75	6.65	.....	.....	8.70	5.60	5.80	7.85	5.30	5.10
5	.....	.....	3.75	3.85	3.80	6.75	.....	.....	8.80	6.55	6.00	8.00	5.30	5.25
6	.....	.....	3.70	3.85	3.70	6.70	.....	.....	8.70	7.45	6.10	7.80	5.75	5.15
7	.....	.....	3.75	3.90	3.80	6.80	.....	.....	8.30	7.35	6.10	8.85	5.30	5.20
8	.....	.....	3.70	3.80	3.75	6.90	.....	.....	8.10	7.25	6.50	8.55	5.10	5.20
9	.....	.....	3.65	3.90	3.75	6.75	.....	.....	7.70	(1)	6.00	8.35	5.20	5.15
10	.....	4.00	3.65	3.85	3.90	6.70	.....	.....	7.60	.....	6.80	8.20	5.10	5.05
11	.....	3.95	3.70	3.55	4.05	6.75	.....	.....	7.50	.....	6.90	7.70	5.30	4.95
12	.....	4.00	3.70	3.85	4.20	6.55	.....	.....	7.30	.....	9.10	7.25	5.25	4.70
13	.....	4.00	3.80	3.75	4.75	6.05	.....	.....	6.30	.....	9.40	7.35	5.25	4.90
14	.....	3.85	3.75	3.70	5.00	6.70	.....	.....	5.50	.....	10.00	7.10	5.25	4.80
15	.....	3.65	3.65	3.75	5.05	6.75	.....	.....	6.00	.....	11.10	7.10	5.05	5.30
16	3.60	3.85	3.50	3.80	5.05	6.80	.....	.....	5.40	.....	11.50	6.75	5.50	4.55
17	3.80	3.85	3.70	3.90	5.50	6.85	.....	.....	5.50	.....	10.80	6.60	5.35	5.00
18	2.50	3.90	3.70	3.75	5.55	6.75	.....	.....	5.40	.....	10.10	6.60	4.65	5.10
19	2.05	3.85	4.20	3.55	7.90	7.10	.....	5.15	5.15	.....	9.40	6.60	4.75	5.10
20	1.90	4.05	4.00	3.70	8.35	7.20	.....	5.20	5.55	.....	8.90	6.35	4.85	5.20
21	1.90	3.80	3.85	3.65	8.30	7.10	.....	5.55	4.65	.....	8.50	6.35	4.75	5.20
22	1.55	3.80	4.00	3.85	8.00	6.80	.....	5.60	4.90	.....	8.10	6.35	4.55	4.80
23	1.05	3.75	4.00	3.45	8.25	6.75	.....	6.00	5.40	.....	7.90	6.40	4.60	4.80
24	.90	3.85	4.00	3.65	7.50	6.80	.....	6.45	5.10	.....	7.70	6.15	4.70	5.10
25	1.05	4.05	4.10	3.70	7.35	7.05	.....	6.40	4.65	.....	7.10	6.05	4.90	5.00
26	.55	3.95	4.05	3.70	7.00	6.10	.....	5.85	5.10	.....	7.20	6.00	5.35	5.20
27	.15	3.90	4.00	3.60	6.65	6.35	.....	5.35	4.10	.....	7.20	5.85	5.25	5.50
28	.05	3.80	3.85	3.65	6.05	6.50	.....	5.35	4.50	.....	7.05	5.75	4.85	5.80
29	.10	3.70	3.95	.....	6.80	6.85	.....	6.30	5.60	.....	5.40	5.85	4.85	5.50
30	.....	3.70	3.90	.....	6.45	6.00	.....	6.75	4.50	.....	6.05	5.95	5.05	5.80
31	.....	3.70	3.85	.....	6.70	.....	.....	.....	4.30	.....	.....	5.60	.....	5.60

Day.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	5.90	5.65	5.90	5.90	7.55	7.55	6.75	5.15	5.05	6.15	6.70	4.85
2	6.00	5.65	5.95	5.85	7.10	7.25	6.80	5.20	4.90	6.25	6.60	5.20
3	6.05	5.60	5.90	5.90	6.80	7.30	6.60	5.10	5.95	6.70	6.25	4.85
4	6.10	5.55	5.90	5.85	7.05	7.70	6.20	5.00	7.80	5.85	5.90	4.85
5	6.10	5.70	5.90	5.90	7.30	8.05	6.25	5.05	6.90	6.40	5.75	4.75
6	6.00	5.70	5.85	6.40	6.75	8.30	6.20	5.25	6.25	5.90	5.70	4.95
7	5.75	5.60	5.95	6.35	6.75	7.80	6.20	5.20	7.05	5.60	5.55	4.80
8	5.80	5.80	5.85	6.65	7.05	7.85	6.35	6.65	7.00	6.70	5.15	5.15
9	5.50	5.80	5.90	7.20	8.40	7.55	6.70	5.10	6.75	7.75	4.70	5.00
10	5.85	5.75	5.90	7.15	8.20	7.35	6.95	5.20	5.90	10.10	4.55	5.00
11	5.55	5.85	5.90	7.15	7.90	7.00	7.20	5.30	6.15	10.40	4.40	4.65
12	5.70	5.75	5.90	6.75	7.95	7.55	6.55	6.20	6.60	10.15	4.75	4.45
13	5.75	6.10	5.80	6.80	7.70	7.25	5.45	7.15	6.15	9.05	5.90	4.80
14	5.70	5.55	5.80	6.65	7.95	6.50	6.00	5.50	5.95	8.30	6.00	5.05
15	5.55	5.60	5.90	6.35	7.70	6.20	5.75	5.30	5.95	7.55	4.60	5.20
16	5.60	5.65	5.85	5.85	7.90	6.10	5.60	5.70	5.90	7.15	4.50	5.30
17	5.60	5.95	5.90	6.45	7.40	6.05	5.80	6.65	5.90	6.90	4.55	5.20
18	5.55	5.90	5.75	6.30	6.55	6.10	6.05	5.90	5.95	6.90	4.55	5.20
19	5.65	5.90	5.65	6.35	6.75	6.50	4.50	5.75	5.90	6.95	4.75	5.10
20	5.60	6.15	5.70	6.15	6.75	6.20	4.60	6.40	5.20	6.25	5.05	5.05
21	5.70	5.85	5.75	6.05	6.85	6.05	5.10	6.10	5.35	6.35	5.10	5.20
22	5.65	5.95	5.80	6.05	7.05	6.10	5.20	6.20	5.05	6.80	5.25	5.70
23	5.60	5.90	5.35	6.10	7.05	6.05	5.30	6.15	5.50	6.65	5.10	5.25
24	5.50	5.90	5.75	7.00	7.05	7.25	4.90	5.85	6.80	6.55	4.95	5.20
25	5.85	5.90	6.00	8.10	8.10	5.00	4.50	5.80	7.10	7.10	4.75	5.45
26	5.55	5.90	5.85	8.35	10.10	6.00	4.60	5.70	7.75	7.20	4.95	5.05
27	5.55	5.90	5.55	8.45	10.60	6.25	5.40	6.00	7.15	6.90	5.45	5.60
28	5.55	5.90	5.70	8.50	9.80	7.25	5.10	5.30	7.20	6.75	5.15	5.95
29	5.55	5.95	5.80	8.20	9.05	6.80	5.50	5.90	6.40	6.85	5.15	5.60
30	5.55	.....	5.70	7.75	8.60	6.30	5.70	6.35	6.10	6.65	4.85	5.50
31	5.50	.....	5.80	.....	7.95	.....	5.50	5.05	.....	6.25	.....	5.15

[1] Chain gage stolen.

Mean daily gage height, in feet, of Wisconsin River at Merrill, Wis., November 16, 1902, to December 31, 1906—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	5.20	5.25	5.35	8.90	5.15	5.80	7.40	5.05	6.10	6.20	6.20	5.20
2	4.95	5.00	5.35	8.80	5.70	5.70	7.30	5.45	6.20	6.00	6.30	5.70
3	5.20	4.90	5.20	9.20	6.20	5.90	7.50	5.35	6.15	6.20	5.60	5.60
4	5.70	5.15	5.40	8.90	6.10	5.50	7.60	5.35	6.70	6.00	5.25	5.80
5	5.35	5.50	5.25	8.80	6.25	7.60	8.00	5.95	6.70	6.05	5.80	5.40
6	5.40	5.35	5.35	8.80	6.40	10.40	8.20	6.10	6.25	6.00	5.35	5.25
7	5.20	5.15	5.55	8.80	6.45	10.00	7.70	6.85	6.00	5.30	5.10	5.55
8	5.45	5.25	5.15	8.20	7.20	9.00	7.80	6.00	6.25	5.30	5.55	5.55
9	5.15	5.10	5.20	8.60	6.70	9.00	8.00	6.25	6.10	4.30	5.45	5.35
10	5.05	5.40	5.65	7.80	6.45	8.40	7.20	6.40	6.30	4.90	5.90	5.75
11	5.35	5.20	5.45	7.40	6.95	8.50	6.85	6.05	6.15	6.15	5.80	5.70
12	5.50	4.95	5.05	7.20	7.20	8.40	7.05	5.75	6.30	6.80	5.15	5.55
13	5.50	5.20	5.45	7.40	6.90	7.80	6.20	6.00	6.65	6.45	5.30	5.60
14	5.90	5.25	4.70	7.00	7.40	7.80	6.30	6.15	6.40	6.55	5.00	5.60
15	6.00	5.15	4.70	6.90	7.60	7.60	6.80	5.90	6.05	5.90	5.20	5.35
16	5.95	5.50	4.95	7.20	7.60	8.10	6.50	6.05	6.40	6.15	5.65	5.70
17	5.75	5.70	5.05	7.40	7.80	10.40	6.30	5.90	6.60	5.85	5.70	6.15
18	5.85	5.65	5.25	7.00	7.80	10.60	6.55	6.40	6.45	6.25	5.75	5.50
19	5.65	5.55	5.25	6.45	7.50	10.60	5.05	6.25	6.90	6.65	5.85	5.60
20	5.15	5.35	5.25	6.45	7.30	9.00	5.65	6.20	7.35	6.85	5.45	5.65
21	5.15	4.30	5.50	6.45	7.00	9.20	6.45	5.90	6.70	6.70	5.75	5.75
22	5.60	5.20	4.95	6.05	6.75	8.60	6.00	6.80	7.30	6.70	5.75	5.75
23	5.80	5.75	4.95	5.95	6.80	8.50	5.50	6.50	6.90	6.80	5.75	5.45
24	6.05	5.80	5.35	5.60	6.40	8.00	5.40	4.80	6.80	6.15	5.60	5.55
25	6.15	5.60	4.55	5.75	6.45	7.60	5.20	5.55	6.50	6.30	5.70	5.90
26	5.85	5.15	5.75	6.20	6.30	6.90	5.10	6.35	6.25	6.70	5.20	6.25
27	5.85	5.65	6.05	5.90	6.35	7.60	5.65	6.40	6.55	6.55	4.80	5.90
28	5.25	5.35	7.40	5.65	6.35	7.50	5.80	6.25	6.15	6.90	5.15	5.60
29	5.10	.....	8.00	5.95	6.25	6.75	5.60	5.75	5.95	6.50	5.65	5.85
30	5.05	.....	8.60	5.45	6.25	7.05	5.75	6.00	6.45	5.70	5.50	5.70
31	5.15	.....	9.50	.....	6.00	.....	4.80	6.80	.....	5.80	.....	5.40

Note.—No ice record at this station.

Daily gage height, in feet, of Wisconsin River, at Merrill, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906.												
1	5.6	5.5	5.75	5.65	7.35	6.55	6.65	4.45	5.85	3.5	6.05	5.9
2	5.75	5.9	5.7	5.7	7.65	6.65	6.45	4.6	6.45	4.5	5.7	5.8
3	6.45	5.5	5.45	6.15	7.8	6.45	7.0	5.2	6.4	4.8	6.0	5.6
4	6.3	5.9	5.2	6.7	7.6	5.85	7.2	5.3	6.35	5.0	5.95	5.5
5	6.85	5.6	5.75	7.65	7.75	7.35	6.85	5.45	6.15	4.75	5.0	5.7
6	5.95	5.65	6.0	7.45	7.75	8.15	6.55	5.05	5.9	5.05	5.75	5.6
7	5.8	5.5	5.65	7.6	7.3	8.25	6.95	5.05	5.6	4.85	5.45	5.45
8	5.7	5.8	5.9	7.5	6.8	7.95	7.5	5.1	5.3	4.45	5.85	5.3
9	5.5	5.6	5.8	8.0	6.45	8.1	5.7	5.15	5.0	4.75	5.65	5.3
10	5.55	5.9	5.4	9.75	6.75	7.75	5.75	5.6	5.0	4.15	5.25	4.8
11	6.05	5.8	4.95	9.8	6.95	7.5	5.7	5.5	4.8	5.3	5.35	5.5
12	5.95	5.65	6.0	9.75	7.0	7.5	5.8	5.9	4.7	5.25	4.9	5.4
13	5.75	5.65	5.6	10.0	6.6	6.7	5.65	4.8	5.55	5.3	5.2	5.7
14	5.8	5.55	6.15	10.05	6.65	6.4	5.8	5.2	5.0	5.0	5.0	5.0
15	5.65	5.7	5.8	9.95	6.65	6.1	5.5	5.05	5.65	4.35	5.65	5.45
16	5.95	5.25	5.9	9.45	6.7	6.1	4.55	5.6	5.7	4.85	5.3	5.45
17	6.35	5.05	6.05	9.2	6.95	5.7	5.6	5.15	3.75	5.15	5.45	5.4
18	6.15	5.1	5.75	9.25	6.4	5.55	5.25	5.2	5.05	5.3	5.15	5.55
19	5.65	5.2	5.6	9.5	6.55	5.85	5.25	5.05	5.45	5.95	5.45	5.5
20	5.65	5.3	5.6	9.55	6.8	6.4	5.15	3.3	5.4	5.1	5.55	5.1
21	5.9	5.75	5.9	9.4	7.2	6.65	5.05	5.6	5.4	5.9	5.75	5.4
22	5.75	5.85	5.75	9.15	6.95	5.8	4.15	6.55	5.75	5.6	5.7	4.95
23	6.0	5.8	5.8	8.85	6.6	5.75	3.5	7.55	5.5	5.6	5.25	5.0
24	5.6	5.65	5.85	8.25	6.55	6.15	5.5	7.15	4.45	5.85	5.1	4.85
25	5.2	5.95	5.6	8.25	6.95	6.7	5.55	6.8	5.55	6.95	5.45	5.35
26	5.5	5.7	5.95	8.0	7.05	6.2	5.15	8.45	5.1	6.65	5.4	5.4
27	5.9	5.5	6.15	7.55	6.4	6.1	4.35	7.75	5.35	6.5	5.5	5.6
28	5.6	5.95	5.7	7.3	6.8	6.05	4.95	7.25	5.0	6.15	6.1	5.7
29	5.7	.....	5.35	6.95	6.55	5.9	5.15	7.1	5.15	6.0	6.3	5.5
30	5.55	.....	5.8	7.4	7.2	6.45	3.8	5.95	4.7	6.1	6.3	5.65
31	5.85	.....	5.65	.....	6.95	.....	5.0	5.45	.....	6.1	.....	4.8

Note.—No ice record by observer. Probably ice conditions during January to March and December.

Mean daily gage height, in feet of Wisconsin River at Merrill for 1907.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1	4.9	5.15	5.2	.....	6.95	5.80	5.8	4.8	4.1	5.3	5.25	4.4
2	5.15	5.0	5.2	.....	6.85	5.40	5.35	4.95	3.5	5.5	5.1	4.35
3	5.0	5.2	5.3	.....	7.30	7.15	5.95	4.75	3.8	5.5	5.05	3.9
4	4.85	5.1	5.45	8.00	7.05	5.20	5.55	4.3	4.05	5.75	4.0	4.4
5	4.8	5.2	4.75	8.50	7.35	5.80	5.6	4.65	4.5	5.45	4.7	4.35
6	4.95	5.15	5.25	8.55	7.60	5.90	5.9	4.6	4.15	5.15	4.9	5.05
7	4.95	5.05	5.2	8.10	7.25	5.75	5.2	4.75	4.65	4.55	4.9	4.6
8	5.0	5.05	5.1	7.90	8.30	5.70	5.6	4.3	4.4	5.15	4.85	4.75
9	5.15	5.2	4.9	7.20	6.90	5.55	5.9	3.8	4.25	5.5	5.15	4.8
10	5.25	4.95	5.4	7.10	6.50	5.20	5.8	4.45	3.3	5.45	3.55	4.4
11	4.9	5.0	5.25	.....	6.80	5.50	5.7	5.55	4.25	5.2	3.85	4.3
12	5.25	5.1	5.05	.....	6.90	5.40	5.5	4.55	4.45	5.3	4.75	4.35
13	5.15	5.25	5.25	.....	6.55	5.95	5.35	4.85	4.85	5.35	3.05	4.35
14	5.05	5.2	5.1	.....	7.65	6.20	5.8	4.3	4.6	4.3	4.2	4.7
15	5.0	4.95	4.75	.....	8.05	5.80	5.3	4.25	4.2	4.75	4.3	4.7
16	5.6	5.3	4.7	.....	8.30	5.85	5.4	4.4	4.8	5.2	4.3	4.55
17	5.1	4.9	4.9	.....	8.35	5.10	5.45	4.3	4.95	5.1	4.55	4.25
18	5.15	5.0	4.75	5.95	8.05	4.70	5.65	4.1	5.1	4.95	4.7	4.3
19	5.25	5.0	5.25	6.20	7.95	4.90	5.5	3.8	8.55	5.15	4.35	4.5
20	5.1	5.05	5.15	6.45	7.50	5.40	5.2	3.95	9.2	4.95	4.9	4.5
21	5.05	5.35	5.4	6.20	7.05	5.40	5.5	4.4	9.1	4.45	5.05	4.7
22	5.0	5.35	5.15	6.90	7.00	5.35	5.1	4.65	8.9	4.55	4.35	4.45
23	5.5	5.1	5.15	7.10	7.00	5.35	5.5	5.0	7.6	4.9	4.35	4.35
24	5.25	5.1	.....	6.90	7.25	5.15	5.4	5.05	7.35	4.85	4.05	4.45
25	5.2	5.1	.....	7.25	7.15	4.90	5.35	5.3	6.95	4.9	4.7	3.95
26	5.3	5.1	.....	6.75	7.20	5.25	5.25	5.15	6.8	4.35	4.3	3.75
27	5.2	5.35	.....	6.20	7.05	5.20	5.20	4.55	6.35	3.85	5.0	4.1
28	5.35	5.05	.....	6.55	6.95	5.60	4.95	4.3	6.0	4.05	4.6	3.95
29	5.05	.....	.....	6.70	6.55	5.15	3.55	4.4	6.0	5.15	4.45	4.85
30	5.2	.....	.....	6.75	6.65	4.90	4.7	4.7	5.6	5.0	4.5	4.55
31	5.25	.....	.....	.....	6.55	.....	4.5	4.55	.....	5.1	.....	4.6

Note.—Reasons are not on record for the intermission of readings in March and April.
Note.—River open all winter, 1907-8.

Rating table for Wisconsin River at highway bridge near Merrill, Wis., from June 17, 1903, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.5	1,485	5.5	3,225	6.5	5,485	8.0	9,565
4.6	1,645	5.6	3,425	6.6	5,725	8.2	10,225
4.7	1,805	5.7	3,635	6.7	5,975	8.4	10,985
4.8	1,970	5.8	3,855	6.8	6,226	8.6	11,545
4.9	2,140	5.9	4,075	6.9	6,475	8.8	12,205
5.0	2,310	6.0	4,305	7.0	6,725	9.0	12,865
5.1	2,485	6.1	4,535	7.2	7,245	9.5	14,515
5.2	2,665	6.2	4,765	7.4	7,785	10.0	16,165
5.3	2,845	6.3	5,005	7.6	8,345	10.5	17,815
5.4	3,035	6.4	5,245	7.8	8,935	11.0	19,465

Rating table for Wisconsin River at Merrill, Wis., for 1905-6.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.50	790	4.80	1,950	6.10	4,210	7.80	8,480
3.60	840	4.90	2,090	6.20	4,240	8.00	9,070
3.70	895	5.00	2,230	6.30	4,640	8.20	9,680
3.80	955	5.10	2,380	5.40	4,860	8.40	10,310
3.90	1,020	5.20	2,540	6.50	5,090	8.60	10,960
4.00	1,090	5.30	2,700	6.60	5,320	8.80	11,620
4.10	1,170	5.40	2,870	6.70	5,560	9.00	12,300
4.20	1,260	5.50	3,040	6.80	5,800	9.20	12,980
4.30	1,360	5.60	3,220	6.90	6,050	9.40	13,680
4.40	1,460	5.70	3,410	7.00	6,300	9.60	14,380
4.50	1,570	5.80	3,600	7.20	6,820	9.80	15,080
4.60	1,690	5.90	3,800	7.40	7,360	10.00	15,800
4.70	1,820	6.00	4,000	7.60	7,910		

Note.—The above tables are applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906. It is fairly well defined between gage heights 5 feet and 8.5 feet. Below gage height 4.5 feet it is only approximate.

Estimated monthly discharge of Wisconsin River at Merrill, Wis., for 1904.

[Drainage agea, 2,630 square miles.]

Date.	Discharge.			Run-off.		Rainfall.[1]
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
	Sec.-feet.	Sec.-feet.	Sec.-feet.	Sec.-feet.	Inches.	Inches.
1904.						
January	4,535	3,225	3,664	1.39	1.60	0.33
February	4,055	3,330	3,749	1.43	1.54	1.20
March	4,305	2,945	3,889	1.48	1.71	1.49
April	11,220	3.970	6,242	2.37	2.64	2.01
May	18,140	5,610	8,935	3.40	3.92	6.20
June	10,560	3,425	6,472	2.46	2.74	4.81
July	7,245	1,485	3,967	1.51	1.74	3,28
August	7,110	2,310	3,766	1.43	1.65	3.21
September	8,935	2,140	5,000	1.90	2.12	4.53
October	17,480	3,425	7,343	2.79	3.22	5.70
November	5,975	1,410	2,800	1.06	1.18	.25
December	4,195	1,490	2,566	.976	1.12	1.86
The year	18,140	1,410	4,865	1.85	25.18	34.87
1906.						
April	16,000	3,320	10,400	3.95	4.41	1.49
May	8,430	4,860	6,230	2.37	2.73	4.76
June	9,840	3,130	5,510	2.09	2.33	5.07
July	7,360	790	3,450	1.31	1.51	2.39
August	10,500	1,700	3,770	1.43	1.65	4.91
September	4,980	925	2,950	1.12	1.25	2.47
October	6,180	790	2,900	1.10	1.27	2.45
November	4,640	2,090	3,170	1.21	1.35	2.60

Note.—Gage heights for 1905 are published in Water-Supply Paper No. 171. Discharge values for 1905 and 1906 are excellent, although logging may affect the results to a slight degree. Ice conditions assumed January, February, March and December. Discharge as given by the measurements on January 24, 1906, is about 50 per cent of the open-channel rating.

Monthly discharge of Wisconsin River at Merrill, Wisconsin for 1907.

Month.	Discharge.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
	Second-feet.	Second-feet.	Second-feet.	Second-feet.	Inches.	Inches.
January	2,700	1,950	2,390	0.91	1.05	1.24
February	2,785	2,090	2,700	1.02	1.06	0.54
March, (a)	2,870	1,820	2,380	0.90	.76	1.45
April, (b)	10,960	5,900	6,300	2.39	1.74	2.25
May	10,160	5,205	6,925	2.63	3.03	1.23
June	6,690	1,820	3,040	1.15	1.28	2.61
July	3,900	1,570	2,870	1.09	1.26	2.81
August	3,040	1,170	1,630	0.62	.71	2.61
September	12,640	690	3,130	1.19	1.33	6.65
October	3,040	990	2,700	1.02	1.18	0.73
November	2,620	490	1,605	0.61	.68	0.52
December	2,305	1,020	1,495	0.56	.64	0.52
The year	12,640	490	3,097	14.09	14.72	23.16

(a) 1-23 only. (b) 20 days only.

Wisconsin River Near Rhinelander, Wis.

This station was established December 1, 1905. It is located about 8 miles southwest of Rhinelander, Wis., at the highway bridge, about 400 feet below Forbes and Wixson's dam and power station.

The channel is straight for 400 feet above and below the bridge. The banks are of medium height, but do not overflow. The bed of the river is rocky and is permanent; the current is swift.

Discharge measurements are made from the lower side of the two-span highway bridge; the initial point for soundings is the right end of the downstream railing of the bridge.

A standard chain gage, which was read during 1906 by E. H. Miller and Charles Hagen, is attached to the upstream side of the bridge. Length of chain, 18.97 feet, The bench mark is the head of the right bolt on the upstream side of the top of the right upstream cylinder pier. It is marked with white paint and the letters "B. M." Elevation, 13.96 feet above the gage datum. The reference point is the center of pulley of gage; elevation, 17.12 feet above the gage datum.

Discharge measurements of Wisconsin River near Rhinelander in 1906 and 1907.

Date.	Hydrographer.	Width.	Area of section.	Gage height.	Discharge.
		Feet.	*Square feet.*	*Feet.*	*Second-feet.*
1906.					
Jan 27	M. S Brennan	209	473	2.71	*a*1,040
April 17	Horton and Brennan	215	822	4.25	2,580
June 12	M. S. Brennan	216	656	3.60	2,050
April 6, 1907	A. H. Horton	211	708	3.94	2,393
April 6, 1907	A. H. Horton	211	785	4.29	2,825
October 17, 1907	G. A. Gray	196	380	2.55	704

a Narrow strip of ice along shore.

Daily gage height, in feet, of Wisconsin River near Rhinelander, Wis., for 1905-6.

Day.	1905.	1906.											
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.5	3.0	2.6	2.8	2.8	3.4	3.1	4.1	2.8	3.1	2.4	2.95	3.1
2	2.4	3.0	2.6	2.5	3.0	3.3	3.2	3.1	2.7	2.4	2.5	3.1	2.15
3	2.25	2.75	3.0	2.95	3.0	3.3	2.8	4.0	3.1	3.0	2.5	3.0	3.0
4	2.4	2.9	2.7	2.95	2.95	3.9	3.1	3.6	3.15	2.9	2.5	2.1	3.1
5	3.0	2.75	2.8	2.4	3.0	3.9	3.2	2.1	1.4	3.3	2.8	2.9	2.8
6	3.1	2.75	2.9	2.9	2.8	4.2	3.6	3.1	3.1	2.6	2.8	3.1	2.3
7	3.05	2.6	3.1	2.8	3.0	3.4	4.3	3.3	2.9	2.5	1.8	2.9	3.0
8	3.1	3.0	2.9	2.4	3.3	3.5	3.9	2.5	3.0	2.8	2.9	2.9	2.65
9	3.2	2.8	2.9	2.7	3.1	3.6	4.3	2.7	3.0	1.7	3.0	2.8	2.9
10	3.0	2.7	2.55	2.8	3.2	3.4	4.4	2.8	2.8	2.1	3.0	2.5	2.7
11	3.0	2.9	2.6	2.6	3.9	3.5	3.5	3.0	2.5	2.5	2.8	2.1	2.9
12	3.2	2.8	2.1	2.6	4.3	3.6	3.6	3.15	2.7	2.7	2.9	2.4	2.7
13	3.1	2.7	2.8	3.0	4.0	3.3	3.5	2.5	2.9	2.6	2.9	2.9	2.85
14	3.2	2.5	2.7	2.95	4.2	3.2	3.4	2.8	2.9	2.4	2.2	2.4	2.8
15	3.0	2.7	2.6	3.0	4.3	2.6	3.2	2.6	2.9	2.8	2.5	2.6	2.8
16	3.05	2.7	2.65	2.7	3.8	3.1	3.2	2.85	2.8	3.0	2.8	2.45	2.6
17	2.85	2.9	2.7	2.75	4.4	3)2	2.8	2.8	2.8	2.4	3.15	2.5	2.7
18	2.9	2.7	2.7	2.5	4.1	3.3	2.4	2.8	2.7	2.5	3.0	1.8	2.3
19	3.1	2.8	2.4	2.7	4.5	3.3	3.0	2.85	1.8	2.5	3.0	2.4	2.9
20	3.1	2.75	2.4	2.8	4.6	3.1	3.1	2.8	2.7	2.5	3.1	2.8	2.5
21	2.7	2.8	2.45	2.8	4.4	3.2	3.2	2.3	2.7	2.7	2.9	2.3	2.7
22	2.95	2.75	2.5	2.7	4.7	3.1	3.5	2.0	2.9	2.6	2.6	2.2	2.7
23	3.3	2.75	2.4	2.5	4.0	3.1	3.3	2.2	3.0	1.8	3.0	2.1	2.5
24	2.9	2.9	3.2	2.7	3.9	3.0	2.5	2.9	3.6	2.3	2.9	2.2	2.5
25	3.0	2.8	2.7	2.9	3.6	2.95	3.1	3.0	3.1	2.4	3.0	1.4	2.9
26	2.7	2.8	2.9	3.0	3.5	3.2	3.2	3.1	2.5	2.45	3.1	2.4	2.6
27	2.9	2.75	2.9	2.95	3.5	1.8	3.7	2.9	2.8	2.4	3.1	2.8	2.2
28	2.7	2.6	3.0	2.8	3.4	3.1	3.1	3.0	3.2	2.4	3.1	3.0	2.8
29	2.6	2.9	.....	2.5	3.9	3.05	3.7	2.9	3.25	2.6	3.1	2.2	2.8
30	2.8	3.0	.....	2.3	3.6	3.6	3.7	2.9	3.0	2.6	3.1	3.1	2.2
31	2.6	2.7	.....	2.7	.....	3.7	.....	2.6	2.9	.....	3.0	.....	2.7

Note.—No ice record.

Mean daily gage height, in feet, of Wisconsin River at Rhinelander, Wisconsin, for 1907.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1	2.7	2.9	2.6	4.6	3.3	4.0	3.1	2.9	1.5	2.6	2.2	1.6
2	2.6	2.4	2.5	4.4	4.1	4.2	3.2	2.4	2.9	2.8	2.8	2.2
3	2.5	2.6	2.5	4.9	3.5	3.6	3.2	2.2	2.3	2.4	1.5	2.2
4	2.5	2.6	2.6	4.5	3.4	3.0	3.1	(1)	2.3	3.1	2.5	2.2
5	2.55	2.9	2.6	4.1	3.7	3.8	3.0	2.2	2.3	2.9	2.8	2.2
6	2.5	2.5	2.4	4.5	3.4	3.2	3.2	2.7	2.3	1.7	2.8	2.3
7	2.3	2.6	2.6	4.4	4.1	3.6	3.4	2.2	2.3	2.8	2.2	2.3
8	2.85	2.6	2.5	3.7	3.4	3.2	3.0	2.2	1.5	2.8	2.2	1.7
9	2.85	2.7	2.5	3.7	3.6	3.9	3.6	2.2	2.1	2.3	2.2	2.2
10	2.8	2.5	2.5	3.5	3.7	3.1	3.2	2.4	2.0	2.8	1.5	2.2
11	2.9	2.6	2.6	3.9	3.6	3.1	3.1	1.5	2.7	2.6	2.7	2.2
12	2.8	3.0	2.5	3.9	4.1	3.0	3.2	2.5	2.1	2.6	2.6	2.2
13	2.6	3.2	2.5	3.8	4.0	3.1	3.8	2.8	2.7	1.4	2.7	2.2
14	3.0	2.6	2.2	4.2	4.3	3.1	3.4	2.2	2.7	2.5	2.2	2.2
15	2.5	3.5	2.5	3.5	4.2	3.1	2.6	2.2	1.0	2.8	2.2	1.7
16	2.4	3.0	2.5	3.2	3.6	2.0	2.7	2.3	2.7	2.7	2.1	2.7
17	2.8	2.6	2.6	3.4	4.3	2.7	3.0	2.2	2.9	2.1	1.5	2.2
18	2.8	3.2	3.0	3.2	4.5	2.5	3.0	1.5	3.3	2.6	2.3	2.7
19	3.0	3.2	2.5	3.4	4.7	2.7	3.1	3.1	3.4	2.4	2.2	2.2
20	2.9	2.8	2.5	3.2	4.3	2.7	3.0	2.9	3.7	1.5	2.5	2.7
21	2.4	2.5	2.5	3.4	4.0	2.8	2.0	2.9	3.8	2.6	2.6	2.7
22	2.4	2.6	2.9	3.5	4.5	3.1	3.0	2.8	3.9	2.7	2.2	2.3
23	2.6	2.6	3.0	3.2	4.2	1.5	3.1	2.7	3.8	2.3	2.2	3.1
24	2.9	2.6	2.8	3.5	3.9	3.1	3.0	2.3	3.9	2.2	1.4	2.7
25	2.8	3.2	3.4	3.1	4.2	2.4	3.0	1.5	3.4	2.7	2.7	1.7
26	2.4	2.5	3.4	3.4	4.2	3.1	3.0	2.9	3.2	2.7	2.2	2.5
27	2.6	2.5	3.6	3.5	3.0	3.2	3.3	2.9	3.2	1.5	2.7	2.5
28	2.8	3.0	3.8	3.7	3.8	3.2	1.6	2.1	3.2	2.4	2.5	2.5
29	3.0	.....	4.3	3.6	3.5	3.2	2.7	2.3	1.6	2.3	2.5	2.5
30	3.0	.....	3.8	3.5	3.8	2.6	2.8	2.9	3.3	2.2	2.1	2.7
31	2.3	.....	4.5	.....	3.6	.....	2.7	2.2	.....	2.2	.....	2.5

Note.—River open all winter, 1907-8.
[1] Water standing in pools.

Railroads.

The railroad facilities of the Wisconsin river are not excelled by any other large river in the state. The Chicago, Milwaukee and St. Paul Railroad parallels the river nearly the entire distance between its mouth and Tomahawk. The Chicago and North-western Railroad crosses the river at Merrimac, Grand Rapids, Wausau, and Rhinelander besides serving other short stretches. The Wisconsin Central has extended its tracks to the various paper and pulp mills in the vicinity of Stevens Point and also between Nekoosa and Grand Rapids. The willingness of the railroads to go where there is an assured traffic is seen at Nekoosa, where, since the development of adjacent water powers, three roads have extended their lines from Grand Rapids south to Nekoosa.

This drainage area is being rapidly cleared and made into farms. This fact insures the certain and steady extension of the competing railroads into this region.

Water Powers.

With the exception of a short stretch of 10 miles, the river, for the first 138 miles above its mouth, occupies a wide, sandy valley entirely devoid of falls or rapids, but showing a very uniform grade of 1.5 feet per mile. This fall is sufficient to create water powers but the width of the valley prevents the building of dams on account of the excessive cost. The flooding damages would also, on account of the low banks, be excessive.

Prairie du Sac Power.—The exception to this condition is found between Sauk City and Merrimac where the river has worn through a terminal moraine, with resulting high banks. A detail survey of this region made in the summer of 1906 by the writer, shows that there is a fall of 28 feet between the highway bridge at Prairie du Sac and a point seven miles above the Merrimac bridge, a total distance of 15.5 miles. The best location for a dam site was found near the north line of Sec. 25, T. 10 N., R. 7 E., at a point 9,000 feet above Prairie du Sac. At this point the river is about 1,150 feet wide and the bed, sand and gravel. It seems certain that a head of at least 15 feet could be here developed at reasonable expense. The legislature of 1906–07 granted a charter for a dam at this point. It is estimated that about 11,000 horsepower can be here developed.

Fig. 1. THE DELLS OF THE WISCONSIN AT THE NARROWS NEAR KILBOURN, WIS.

THE DELLS OF THE WISCONSIN RIVER.

Fig. 2. Low water. Fig. 3. High water.

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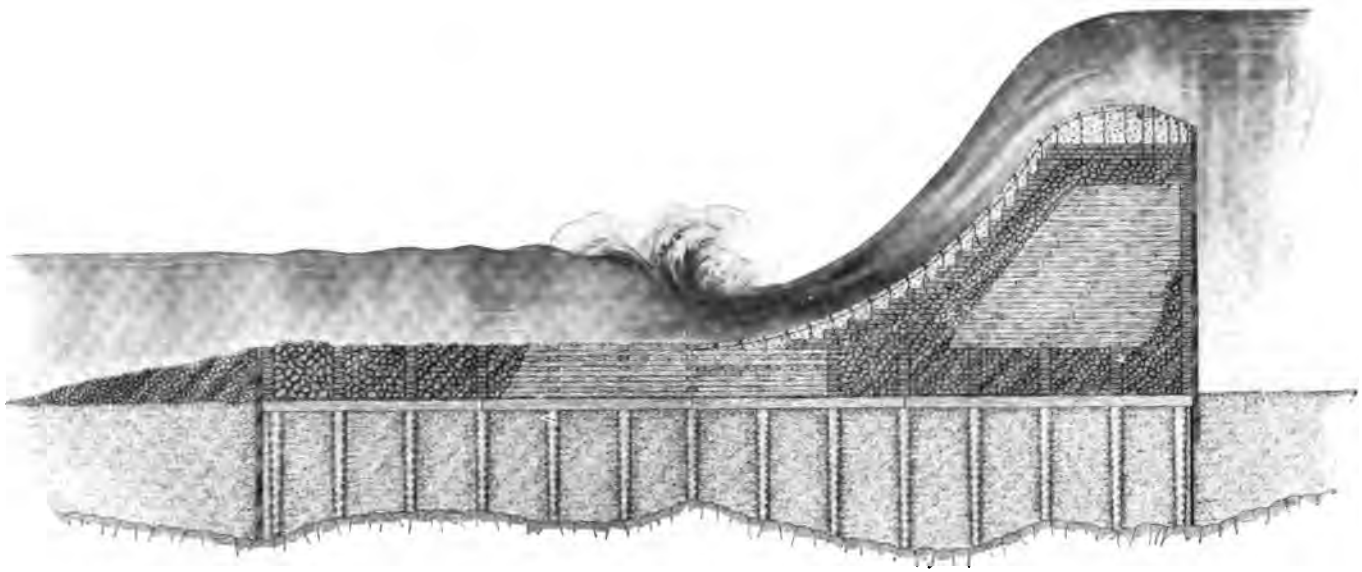

CROSS-SECTION OF KILBOURN DAM NOW UNDER CONSTRUCTION.

The drainage area tributary is about 1,100 square miles greater than at Kilbourn.

Kilbourn.—Between a point about four miles above Kilbourn and one two miles below, the Wisconsin river flows through a relatively narrow and deep gorge in the Cambrian sandstone, known as the "Dalles." In this distance the river varies in width from 500 to 40 feet in the narrowest part. At this latter point the water has a depth of 45 feet. Plate XX gives a view near the Narrows during high and low water.

A timber dam with a crest of 3 feet was for many years used at Kilbourn for running a flour mill. The dam was blown out by lumbermen 30 years ago and no use has been made of the power since. In 1905 the Southern Wisconsin Power Company was organized to utilize this valuable power. A former legislature had granted a charter for a dam with a 15 foot crest with the privilege of 2 feet of flashboards, giving a total head of 17 feet. The above company have acquired this franchise and all needed riparian rights and plans have been prepared for a dam to be located a short distance below the present dam. The contract has been let for a turbine installation of 8,000 h. p. A cross-section of the dam is shown in Plate XXI.[1]

The river continues to flow in the Cambrian sandstone for the entire 68 miles between Nekoosa and Kilbourn, in which distance the river has a fall of 105 feet. This fall, however, is too evenly distributed to furnish good dam sites. Moreover the banks are low and sandy. The river has a sinuous course, the outer banks as a rule being steep and sandy while the inner ones are low and flat. There are two sites where a head of nearly ten feet could be developed, both of which would have large ponds and much overflowed land.

Necedah Dam Site in Section 36, Township 18 North, Range 5 East.—This dam site is located just below the mouth of Big *Roche á Cris* river. At this point the river is only 500 feet wide. The left bank is formed by perpendicular rocks of Cambrian sand stone 80 feet high. The right bank, however, is sandy and only 10 feet above low water, making necessary a dyke 1,000 feet long or more. This site is 6 miles from Necedah, a point reached by both Chicago, Milwaukee and St. Paul and Chicago and North-western railroads.

Dam Site in S. E. ¼ Section 21, Township 20 North, Range 5 East.—Near the south line of the above quarter section, at what is still called "Old Barnum," there was, many years ago a low dam devel-

[1] Designed by D. W. Mead.

oping a head a few feet and probably used for boom purposes. There is a small riffle here over a gravel bottom with banks of sand and clay. While not a good dam site, a head of nearly 10 feet could be secured by a dam 1,000 feet long. In both of the above powers unusual attention will need to be directed to constructing the dam so as virtually to give a free river in time of floods.

Nekoosa.—At Nekoosa, 206 miles above the mouth of the river we find the river flowing for the first time in the pre-Cambrian crystalline rock. As a result the river has an increased gradient while conditions for dam construction are much more favorable. In a distance of 8½ miles between the crest of the Grand Rapids dam and the tail race of the Nekoosa dam the river falls 82 feet, 68 feet of which is already developed by four dams. At Nekoosa a rock crib dam 17 feet high and 700 feet long develops a head of 17 feet. The dam extends from an island near the west shore to the east or left bank of the river. A view of this dam is shown in Plate XXI. The power house and head gates are located across the narrow western channel. Turbines to the number of 37, rated at 4,560 actual h. p. (24 hour day), are installed. The power is used to operate a modern paper and sulphite mill, one of the largest on the river. A view of this mill is shown in Plate XXII. The drainage area above Nekoosa is about 5,700 square miles. The head at this dam could be increased about 2 feet by blasting out a deeper and larger tail race. Three railroads compete for the Nekoosa freight, the Chicago, Milwaukee and St. Paul, Chicago and North-western, and Wisconsin Central.

Port Edwards.—The John Edwards Manufacturing company, located at Port Edwards, owns a fully developed power used to operate a paper and pulp mill. A rock crib dam, 10 feet high and 900 feet long, at the head of a long island produces a head of 18 feet.

The Company have installed 28 turbines rated at 3,860 actual h. p. This power enjoys the same railroad facilities as at Nekoosa.

South Centralia.—This dam, a view of which is shown in Plate XXII. is located two miles above Port Edwards. Its total length is 1,000 feet including 100 feet occupied by a small island. The dam is of the rock crib type and 9 feet high.

Turbines rated at 1,460 h. p. are installed under a 12 foot head and used in the manufacture of pulp and paper by the owners, the Centralia Pulp and Water Power Company. The mill is located on the right bank.

Fig. 1. NEKOOSA PAPER CO.'S DAM, NEKOOSA, WIS.
Wisconsin River. Head 17 feet.

Fig. 2. SOUTH CENTRALIA PULP CO. DAM AT SOUTH CENTRALIA, WIS.
Head, 9 feet.

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NEKOOSA PAPER CO.'S PLANT, NEKOOSA, WISCONSIN.

The bed and banks are both in the crystalline rock. The latter rise to a height of 25 feet above the crest of the dam. From the tail-race of the Grand Rapids Paper Mill, 2½ miles above, to the crest of South Centralia dam, there is a fall of about 8 feet, nearly five feet of which could probably be added to the crest af the Centralia dam.

This dam and mill are said to be the oldest extant development on the river. It enjoys the same railroad facilities as the two powers below.

Grand Rapids.—One of the largest and most complete paper and pulp mills in the entire State, owned by the Consolidated Paper and Power Company, is located on the west side of the river, within the city limits of Grand Rapids. This mill was erected in 1902 and its installation of paper-making machinery has all the recent important improvements. Before this mill was constructed there was a total descent of 30.8 feet between the foot of Biron dam, 4 miles above, and the Grand Rapids bridge. Of this amount the new masonry and concrete dam of the Consolidated Paper and Power Company develops a head of about 25 feet. Sixteen 40 inch turbines of 6,500 h. p. are already installed, flume space being also provided for the development of an additional 1,000 h. p. for future expansion. Prior rights of 500 h. p. developed by this dam are owned by the Grand Rapids Milling Company, which uses it in the manufacture of flour.

The Pioneer Wood and Pulp Company has certain rights to about 600 to 800 h. p. "when the stage of the river will permit," which has meant about ten months each year. This power is used by the company for grinding wood pulp. The Grand Rapids foundry also has rights to about 40 h. p. from the same dam. The milling company and the foundry both receive their power from the Consolidated Company in consideration for power previously owned by them and displaced by the present dam.

The above described paper mill has the advantage of competition in freight rates, incident to being served by each of the following railways:—The Chicago and North-western; Chicago, Milwaukee and St. Paul; Green Bay and Western, and Wisconsin Central.

A view of the dam and paper-mill is shown in Fig. 1 of Plate XXIV.

Biron Dam.—About 3 miles above Grand Rapids is located the Grand Rapids Pulp and Paper Company mill. A head of about 12 feet is developed at the plant 500 feet below the dam which is 10

feet high and 2,200 feet long. This dam, a view of which is shown in Plate XXIV, is mostly of rock crib construction but is partly of concrete. It is built in three sections, there being two islands intervening. The waste gates are placed on the west (right) side. The power plant and mill are located at the lower end of a small island and span the narrow channel between the island and the east (left) bank. The company have 18 turbines installed and rated at about 3,000 actual h. p. The Company is served by the Green Bay and Western Railroad. In the 13 miles between the crest of the Biron dam and the foot of the next one above, near Stevens Point, Wisconsin River descends 16 feet. The only rapids in this distance is one of 3½ feet called "Crooked Rift," about 4 miles above the Biron dam. The greater part of this fall properly belongs to the Biron power and is largely developed by the splash boards of that dam.

Stevens Point Power.—Owing to the peculiar topography of the river valley between Nekoosa and Stevens Point, whereby the adjacent tributaries flow for long distances parallel to the main river, and to the decided narrowing of the river valley between these points, the discharge of Wisconsin River at Stevens Point does not differ greatly from that at Nekoosa. The drainage area at Stevens Point is about 5,600 square miles.

From the crest of the upper dam in the city of Stevens Point to the foot of the dam, near the mouth of the Big Plover River 3½ miles below, the river has a fall of 42 feet formerly known as Conant's Rapids, 32½ of which has been developed at three dams as described below.

The Plover Paper Company Dam.—The lowest of the three dams is located on the east (left) bank of the river 1,000 feet below the mouth of Big Plover River at a point where the river is nearly 1,500 feet wide. Advantage, however, is taken of a large high island at this point which reduces the length of the dam to less than 1,000 feet. This dam was built in 1892–3. It develops a head of 9 feet. The company have installed 8, 72-inch wheels, rated at 1,370 h. p., used in the manufacture of the better grades of paper.

The officers of this company are George Whiting, President; C. A. Babcock, Secretary, and C. E. Edwards, Treasurer.

The Green Bay and Western Railway has a spur to this mill.

The Wisconsin River Paper and Pulp Company.—This company own and operate the next dam above and located only a half mile above the Plover dam. The dam is built obliquely to the stream with

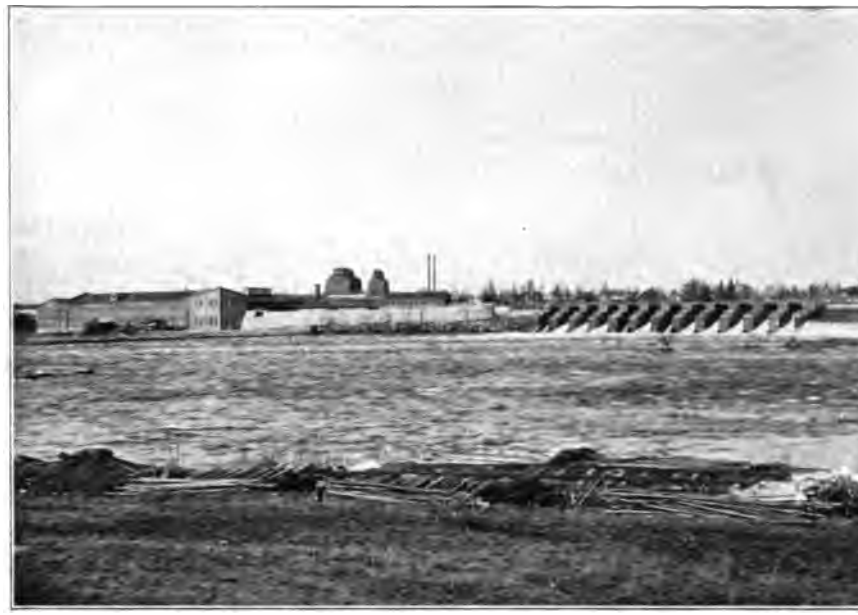

Fig. 1. THE CONSOLIDATED PAPER AND POWER CO.'S DAM AND MILL, GRAND RAPIDS, WISCONSIN.
Head. 25 feet.

Fig. 2. GRAND RAPIDS PULP AND PAPER CO.'S PLANT AT BIRON, WIS.
Head, 12 feet.

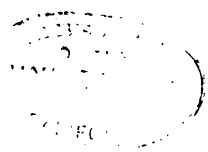

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Fig. 1. UPPER PAPER MILL DAM, CONANTS RAPIDS, NEAR STEVENS POINT.
Head, 17 feet.

Fig. 2. BROKAW PAPER CO.'S DAM AT BROKAW, WIS. WISCONSIN RIVER.
Head, 15 feet.

a decided angle near its center pointing up stream. The average head developed is 17 feet, and the turbines installed number 16, rated at 4,660 h. p. The crest of this dam could be raised to 20 feet. The officers of this company are the same as of the Plover dam. A spur from the Wisconsin Central Railway extends to this plant. A view of this dam is shown in Fig. 1 of Plate XXV.

Jackson Milling Company Dam.—This dam is an old rock crib dam 7 feet high and 800 feet long built in 1845 and located in the city of Stevens Point about 1,500 feet below the wagon bridge. The owners have installed only 3 turbines rated at 140 h. p. used to operate a flour and feed mill.

Surveys have been made and plans drawn for a new dam replacing the old one, to be located 1,000 feet below the present structure. Such a dam would develop a head of about 12 feet and it is estimated would develop 1,800 h. p. The above company own the undeveloped fall included in this project. On account of its location in a growing city of 10,000 people it would seem that this power would easily find takers at remunerative rates.

The officers of the company are J. P. Witter, President; Guy Nash, Secretary. The Green Bay and Western Railway has a side track to this mill.

Battle Island Dam Site.—In the 21 miles between the Jackson Milling Company's dam and the Chicago, Milwaukee and St. Paul Railroad bridge near Knowlton the river has a fall of only one foot to the mile. In this stretch there is only one opportunity for the development of water power, *viz.*, either about 1,000 feet above or 1,000 feet below Battle Island in Sections 28 and 33, Township 26 North, Range 7 East, respectively. A 700 foot dam would here develop a head of about 14 feet before backing water on the next rapids above. Rock and timber are very abundant and near at hand, in fact the bed and banks of the river are in rock, while the Chicago, Milwaukee and St. Paul Railroad is only a mile distant from the dam site. A charter for a dam at this point has been secured by Gunther and Wintin.

Mosinee Dam.—One of the best and most easily developed powers on the river, formerly known as Little Bull Falls, is located at Mosinee in the hard crystalline rocks.

The power which is owned by Joseph Dessert is partly developed but only 30 h. p. is at present used for electric lighting. In 1860 the first dam was built at the head of the islands which crowd the

channel at this point. Later, the dam was reconstructed so as to develop a head of 12 feet at the saw mill. The saw mill is equipped with two wheels rated at 685 h. p. but only steam power is used. If the present dam which is only 6 feet high, were raised two feet, a head of 20 feet could be developed near the present saw mill, though some blasting would probably be required at the tail-race. The Chicago, Milwaukee and St. Paul Railway depot is on the immediate east bank. This power has been recently sold to Wausau capitalists. A view is shown in Figure 9.

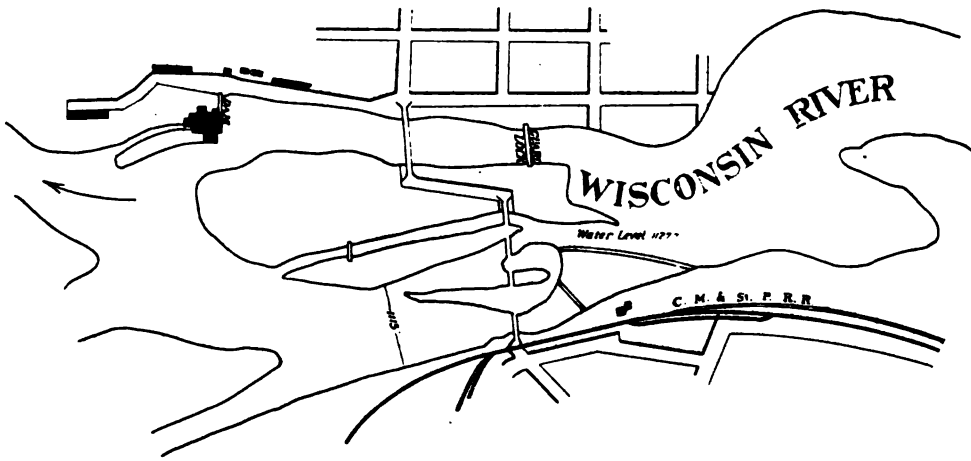

Fig. 8.—Map of water power at Mosinee, Wis.

Rothchilds Dam Site.—Between the town line between Townships 28 and 29 in the city of Wausau and the crest of the Mosinee dam, a distance of 15 miles, Wisconsin River descends 23 feet. In this distance there are two sites where a dam could be constructed at a reasonable expense which would develop a head of about 18 feet. In the S. E. ¼ of Section 34, Township 28 North, Range 7 East, the gravel banks though not steep, are high enough with a dam about 1,000 feet long.

About 2½ miles above this point in Section 24, Township 28, Range 7 East, at a place called Rothchilds, a head of about 18 feet could be developed. The right bank is high and steep but a long dam would be required to meet the high ground on the left side.

Rib and Eau Claire rivers, with drainage areas of 500 and 423 square miles, respectively, enter Wisconsin River from opposite sides but a short distance above Rothchilds. This place is 7 miles from

Wausau, a growing city of about 15,000 inhabitants, and on the Chicago, Milwaukee and St. Paul Railroad.

Timber is plentiful and the hard crystalline rocks outcrop at the Rothchilds site.

Wausau Dam.—A rock crib dam 6 feet high and 200 feet long occupies the west channel of the river at the head of Big Bull Falls. In the middle of the river is a high granite island nearly 2,000 feet long. Directly opposite the dam and occupying the east channel under the Scott Street High bridge is the guard lock which regulates the flow to the three installations near the lower end of the island. At the head of this island and on the west side of it, is situated the H. E. McEachron Grain and Milling Company's plant which under a head of 8 feet develops from 100 to 125 horsepower. They have 3 wheels installed 60, 40, and 38 inches in diameter, respectively. A thousand feet below the guard lock, the Wausau Electric Company recently (1905) built a concrete dam about 150 feet long and varying from 10 to 25 feet high. By blasting a tail race out of the solid rock they have secured a head of 22 feet. Two pairs of turbines are installed rated at 732 horsepower per pair; and according to their estimate they will develop 1,200 actual horsepower. This company acquired rights to two-ninths of the total flow of the river. The officers are R. E. Parcher, President; H. C. Stewart, Vice President; F. P. Stone, Treasurer, and W. F. Collins, Secretary.

Across the channel from the plant of the Electric Company is a good power plant owned by D. L. Plummer, who has rights to four ninths of the total flow of the river. He has a rock crib dam developing a head of about 14 feet. The head could be increased to equal that of the Electric Company by blasting out of the rock a new tailrace about 400 feet long.

Five hundred feet below the two foregoing developments and occupying another channel to the eastward, is the saw mill of the Alexander Stewart Lumber Company, where about 500 horsepower is developed under an average head of 16 feet. By blasting out a new tail race for 1,500 feet below the mill, the present head could be increased to 23 feet. Surveys for such an improvement have been made, the intention being to use power to operate a large paper mill to be erected on this site. This company owns three-ninths of the total flow of the river.

The crest of the main dam at Wausau could be raised 3 feet without endangering valuable property. Wausau has the advantage of competitive freight rates, being served by the Marshfield Branch of the Chicago and North-Western Railroad and the Wisconsin Valley Division of the Chicago, Milwaukee and St. Paul Railway.

Brokaw Dam.—In the 20 miles (by river) between the foot of the lower dam at Merrill and the head of the Wausau dam, Wisconsin River descends about 55 feet, 35 of this being between Wausau and the mouth of Pine River. The only portion of this fall at present developed is at Brokaw.

The tail water of the Brokaw dam is 5.6 feet above the crest of the Wausau dam, the distance (by river) being 5.3 miles. The Brokaw dam, a view of which is shown in Plate XXV, is 350 feet long and 15 feet high, the length being greatly reduced by the island which occupies fully ½ the width of the stream. The dam develops about 4,000 actual horsepower under an average head of 15 feet. The power is used to operate a large paper and pulp mill owned by the Wausau Paper Mills Company who have installed the following 13 turbines:

Number.	Size.	Horse power. Each.	Total H. P.
8	60 in.	375	3,000
3	54 in.	300	900
2	37 in.	600	1,200
			5,100

Walter Alexander is president of the company, Alexander Stewart, Vice President. W. L. Edmonds, Secretary and Manager, and E. A. Edmonds, Treasurer. Brokaw is reached by the Wisconsin Valley Division of the Chicago, Milwaukee & St. Paul Railroad. By increasing the length and height of this dam at Brokaw a head of 20 feet or more could be maintained, but not without considerable flooding.

Trapp Rapids.—In the 14.5 miles from the foot of the lower dam at Merrill to the Brokaw dam, the river has a descent of 32 feet. From 15 to 20 feet of this could be developed by a dam 1,000 feet long in S. E. ¼, Sec. 2, T. 30 N., R. 8 E.; or a dam 1,200 feet long in S. E. ¼, Sec. 14, T. 30 N., R. 8 E., at Trapp Rapids just above the mouth of Trapp River would develop a head of from 20 to 25 feet. The rights of this latter site are owned by G. D. Jones,

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NEAR THE FOOT OF GRANDFATHER RAPIDS, WISCONSIN RIVER.
The river has a fall of 90 feet in 1½ miles.

Neal Brown, and Carl Mathie of Wausau. The bottom and banks are gravel at both sites, timber is abundant and the Chicago, Milwaukee and St. Paul Railway is close to the left bank of the river.

Merrill Powers.—Within the corporate limits of Merrill, a city of 9,000 inhabitants, are located two dams about 2.3 miles apart. The lower dam is a rock crib structure 11.4 feet high and 500 feet long belonging to the Merrill Railway and Light Company.[1] This company has installed on the left bank a power plant of 5 turbines (4, 42-inch and 1, 72-inch) which develop 650 horsepower. The remainder of the power they have leased to the Lindauer Pulp and Manufacture Company and to Wendt and Company.

The Lindauer Company[2] have installed 25, 35-inch turbines under a head of 13.5 feet and rated at 2,500 horsepower. At ordinary stages of water, however, they are able to run only 15 turbines.

Wendt and Company operate a flour mill on the right bank at the south end of the dam using about 100 horsepower obtained from one 35-inch turbine.

The above dam could not have its crest raised without flooding the dam above. The upper dam is 700 feet long and develops a head of 5½ feet, but is used only for boom purposes. This dam is owned by the Wisconsin River Driving Association as is also an old dam about 2 miles above. Both are timber dams and in need of repair, especially the upper one, a view of which is shown in Plate XXVI.

As there is but little need of these dams for boom purposes at present it has been proposed to replace both dams by a larger structure to be located in Sec. 9, T. 31 N., R. 6 E. The river is here less than 500 feet wide but the left bank slopes so gently that a dyke 1,000 or 1,500 feet long might be required to develop a head of 20 feet. This would back the water to the foot of the next rapids above.

Bill Cross Rapids.—These rapids include a fall of 9 feet, all located in Section 13, Township 32 North, Range 5 East, at a distance of 5 miles from the Chicago, Milwaukee and St. Paul Railway. A dam 1,100 feet long would here develop a head of 20 feet and back the water to near the foot of the next rapids above known as Grandfather Falls or Rapids.

Grandfather Rapids.—In the 53 miles below the foot of the Rhinelander dam the river has a natural descent of 277 feet, an aver-

[1] The officers of the company are J. N. Cotter, President; John O'Dea, Vice President, E. S. King, Secretary and Treasurer.

[2] The officers of the Lindauer Company are L. Lindauer, President; George O'Connel, Vice President, and George Klein, Secretary and Treasurer.

age of 5.2 feet per mile. In this stretch, besides several other fine powers, are included Grandfather Rapids, the largest water power on the river, developed or undeveloped. These rapids begin in the N. E. ¼ Section 30, Township 33 North, Range 6 East, and extend to the S. W. ¼ Section 31, a distance of 1½ miles, and are the most noted rapids on the river. A view of them is shown in Plate XXVII The descent in this distance is 89½ feet. The high bank and the bed of the river are in the hard pre-Cambrian rock. For nearly thirty years the Wisconsin River Logging Association has maintained three logging dams on these falls.

The legislature of 1905 granted the right, Chapter 464, to E. T. Harmon, L. N. Anson, Ben Heineman and John O'Day to build and maintain a dam across the river in Section 30, Township 33 North, Range 6 East, the height of which was limited to 32 feet.

This dam is built of masonry 35 feet high and develops a head of 31 feet. Plate XXVIII shows a view of it when nearly completed. The owners estimate the power at 4,000 h. p. and report that about one-half of this amount will be transmitted to Merrill electrically and used in running a paper mill at that place.

The above dam will develop the upper third of Grandfather Falls, leaving still undeveloped about 60 feet of head below. It seems probable that the best way of developing this lower 60 feet will be by means of two dams.

Detail surveys of this stretch with a view of development have recently been made and construction will likely be begun in the near future as soon as capital can be interested. Mr. R. L. Kraus of Marshfield, Wisconsin, is the owner of all the lands on the left (east) bank of the river from the Grandfather Falls Company lands to the foot of the falls, while the Alexander Stewart Lumber Company of Wausau, Wisconsin, owns all of the land on the right (west) bank. These owners are said to be cooperating in the effort to secure a development of this important power.

The drainage area of Wisconsin River at Grandfather Falls is nearly 2,500 square miles. The Chicago, Milwaukee and St. Paul Railway is located about 4½ miles east of this dam site.

Grandmother Rapids.—In the 5 miles between the head of Grandfather Falls and Grandmother Rapids the river has a fall of about 3 feet to the mile, a fall that can best be developed as a part of the Grandfather Falls power.

NEW DAM, COMPLETED 1907, DEVELOPING THE UPPER THIRD OF GRANDFATHER RAPIDS, WISCONSIN RIVER.
Head about 31 feet.

Fig. 1. GRANDMOTHER RAPIDS. WISCONSIN RIVER.

Fig. 2. OLD DAM SITE ON WISCONSIN RIVER ABOVE MERRILL, WISCONSIN.

Grandmother Rapids is the name given to a short stretch of rapids located near the north line of Section 10, Township 33 North, Range 6 East and comprising a fall of 4 feet in a quarter of a mile. A view of these rapids is shown in Plate XXVI.

Chapter 145, Laws of 1903, grants a charter to build a dam at these rapids to Edward Bradley and W. G. Collins. No head is specified in this charter but a head of about 17 feet would develop all the fall to the Tomahawk dam. No work on this development has yet been done. Grandfather Falls is in the crystalline rocks with plenty of timber near at hand. The Chicago, Milwaukee and St. Paul Railroad is about 4½ miles distant.

Tomahawk Dam.—This dam, which has a head of 13.2 feet, is located in the S. W. ¼ Section 10, Township 34 North, Range 6 East. It has a total pondage of over 4 square miles, the largest on the river, backing up the water in the main river for about 6 miles, as well as in the tributaries. The steadying effect which this dam exerts, together with that of several dams on adjoining lakes, must be very beneficial.

The main part of the Tomahawk dam containing the waste gates is 14 feet high and 650 feet long. There is, however, about one-half mile of wing dams which assist in holding the pondage. This power has been used for several years for running a large paper mill located on the left bank and reached by spur tracks of the Chicago, Milwaukee and St. Paul Railway. The installation is 650 h. p. During the summer of 1904 another paper mill was erected on the opposite bank, taking its power from the same dam.

This mill has installed 6, 66-inch, 1, 60-inch and 1, 48-inch wheels.

The dam and mills are owned by the Tomahawk Pulp and Paper Company.[1] Two railroads, the Chicago, Milwaukee and St. Paul and the Marinette, Tomahawk and Western compete for the freight.

Pine Creek Rapids.—From the foot of Whirlpool Rapids to the backwater of the Tomahawk dam, a distance of 10 miles, the river has nearly even descent of 23½ feet, 20 feet of which could be developed by one or possibly two dams. A 20 foot dam located about a mile east of the city of Tomahawk, in the S. E. ¼ Section 25, Township 35 North, Range 6 East, would back the water up into Pine River. Most of the land thus to be overflowed belongs to lumbering

[1] The president of the company is C. B. Pride. Other officers are R. C. Pride and B. A. Pride.

companies or to the Bradley Company, of Tomahawk, Wisconsin. This dam site is less than half a mile from the Marinette, Tomahawk and Western Railway.

Whirlpool Rapids.—These rapids extend from the west line of Section 12, Township 35 North, Range 7 East, to the north line of Lincoln County, a ditsance of about 2 miles, in which the river descends 15.4 feet. Between the head of Whirlpool Rapids and the foot of Hat Rapids there is a descent of 12.63 feet. A suitable dam at the foot of Nigger Island, in Section 12, Township 35 North, Range 7 East, would develop a head of 28 feet. The banks are said to be high with an abundance of rock and timber adjacent to the dam site. The drainage area at this point is 1,300 square miles. Three different railroad lines are located within 3 or 4 miles of this site, and Tomahawk, a city of 2,500 population, is 7 miles west.

Hat Rapids.—Between the mouth of Pelican River and the foot of Hat Rapids in Section 27, Township 36 North, Range 8 East, the Wisconsin has a natural fall of 20 feet, and a drainage area above this point of 1,220 square miles.

In 1905 the Rhinelander Power Company was organized to develop these rapids. The present officers are A. W. Shelton, President, C. A. Wixon, Secretary, and Charles Chafee, Treasurer.

A concrete dam shown in Plate XXIX, 140 feet long with earthern wing dykes of 180 and 240 feet in length was built in 1905.

This developes a head of 20 feet. being all the fall available between the south line of above section 27 and the Rhinelander dam 6 miles above.

In the concrete power house are installed 6 34-inch horizontal turbines rated at 2,400 h. p. The 400 K. W. generators are directly connected to the turbines. The electricity is transmitted to Rhinelander, a growing city of over 5,000 inhabitants, where it is leased for power and lighting purposes.

Rhinelander Dam.—Between the foot of the present dam of the Rhinelander Paper and Pulp Company, in the city of Rhinelander, and the foot of Otter Rapids, in Section 36, Township 40 North, Range 9 East, a distance of about 35 miles, the river descends 79.2 feet. The dam develops 30 feet of this descent, and the power is used to run one of the largest paper and pulp mills on the river. The company has installed turbines rated at a total of 3,000 actual h. p. and has also 1,200 steam h. p. The daily capacity of this mill is

Fig. 1. RHINELANDER POWER CO.'S DAM AT HAT RAPIDS, WISCONSIN RIVER.

Fig. 2. RHINELANDER PAPER CO.'S MILLS, RHINELANDER WISCONSIN.
Cost over $1,000,000.

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Fig. 1. LOWLAND SCENE ON THE UPPER WISCONSIN BETWEEN CONOVER AND EAGLE RIVER.

Fig. 2. DAM AND POWER HOUSE AT EAGLE RIVER, WISCONSIN.
Head, 16 feet = 425 h. p.

45 tons of finished paper, 40 tons of pulp, and 40 tons of sulphite pulp. A view of this mill is shown in Plate XXIX.

The river above this point has a drainage area of about 940 square miles. Above Rhinelander the river banks are lower and the opportunities for developing large powers few. In the 35 miles between Rhinelander and the source there are two rapids, called Rainbow Rapids and Otter Rapids. In this distance, according to the United States engineers, between the head of Otter Rapids and a point about a mile above the mouth of Pelican River, the descent of Wisconsin River is only 57 feet, or about 1.62 feet per mile.

Rainbow Rapids.—These rapids are of small extent. They are located in Section 6, Township 38, North, Range 8 East, and a head of 6 to 10 feet could be secured.

Otter Rapids.—The most important power above Rhinelander is at Otter Rapids, where a logging dam with a head of about 10 feet was early constructed. The rapids proper descend 16 feet, so that a head of this amount or more could be developed. The dam site is between lots 6 and 8, Section 36, Township 40 North, Range 9 East. The drainage area above this point is about 500 square miles. According to the Chicago and North-western Railway, the Wisconsin River at Conover, in Section 9, Township 41 North, Range 10 East, has an elevation of 1,644 feet above the sea. This would give a fall of 66 feet in the 24 miles between Conover and the head of Otter Rapids. A view of the lowlands in this portion of the river is shown in Plate XXX.

Tributaries of Wisconsin River.

GENERAL STATEMENT.

The watershed line on each side of the Wisconsin Valley is between 300 and 400 feet above the main river, and as the tributaries have to descend this distance in a length of 50 or 60 miles they have many rapids and available powers. In the upper portion of their courses the tributaries flow over the hard pre-Cambrian rock, giving many rapids. The lower valleys, however, are filled by continued erosion, so that with few exceptions, no powers are found here.

The length and drainage area of certain streams tributary to Wisconsin River are shown in the following table:

Principal tributaries of Wisconsin River.

River.	Length.	Drainage area.
	Miles.	*Sq. miles.*
Pelican	25	262
Tomahawk	50	714
Rib	50	498
Eau Claire	50	423
Eau Pleine	50	377
Yellow	70	946
Lemonweir	50	588
Baraboo	70	655
Kickapoo	75	760

Only Kickapoo, Baraboo and Lemonweir rivers and their branches have been as yet fully or even largely developed, but the present rapid settlement of this northern region is fast bringing a demand for the utilization of these valuable water-power resources. While these powers are small as compared with those on the main river, in the aggregate they are large, and their wide distribution makes them of still greater value. In some cases, because of the ease with which they can be developed and controlled, manufacturers seem to prefer them to the larger but more expensive powers on the parent river. An example of this is seen in the present power developments on Prairie River.

ST. GERMAIN RIVER.

Although but 20 miles long, St. Germain River has at least three good dam sites located as follows: (1) SW. ¼ sec. 31, T. 41 N., R. 8. E.; (2) near the outlet of Big St. Germain Lake, sec. 32, T. 40 N., R. 8 E.; and (3) near the northeast corner of sec. 18, T. 39 N., R. 8 E. At the second dam site a head of 20 feet and at the third site a head of 26 feet are reported as feasible.

TOMAHAWK RIVER.

This river rises in about 40 lakes with elevations of from 1,540 to 1,575 feet above the sea, the largest of which is Tomahawk Lake, with an area of 7 square miles. The river joins the Wisconsin at Tomahawk after a course of about 50 miles.

The dam in Wisconsin River at Tomahawk backs the water in Tomahawk River to an elevation of 1,431 feet, so that the remaining descent is about 120 feet, or 2.4 feet per mile, nearly half of which

is concentrated in four rapids. Only one of these has been developed for power purposes, the dam being located about 2 miles above the mouth of the river, where a head of about 18 feet is obtained. At present only 300 horsepower are here utilized, in a tannery belonging to the United States Leather Company. A view of this dam is shown in Plate XXXI, figure 1.

Eight miles above this dam in lots 5 and 6, sec. 21. T. 36 N., R. 6 E., are the Prairie rapids, with a descent of 20 feet; 10 miles above in lots 1 and 4, sec. 17, T. 37 N., R. 6 E., are the Halfbreed rapids, with descent of 8 feet; and 12 miles still farther upstream in sec. 27, T. 38 N., R. 5 E., are the Cedar rapids, with descent of 12 feet.

PELICAN RIVER.

This river rises in a series of lakes, the largest being known by the same name, at an elevation of 1,590 feet above the sea. The river flows west and joins the Wisconsin near Rhinelander, after descending about 50 feet in its length of 25 miles. The following table shows the location of promising dam sites, none of which are as yet developed.

Dam-site Locations on Pelican River.

	Possible head (feet).
Between lots 4 and 6, sec. 4, T. 36 N., R. 10 E.	6 to 8
SW. ¼ sec. 17, T. 36 N., R. 10 E.	6
Between lots 3 and 4, sec. 26, T. 36 N., R. 9 E.	10
Between lot 1, sec. 21, and lot 1, sec. 22, T. 36 N., R. 9 E.	12

PRAIRIE RIVER.

Although Prairie River has a drainage area of only 214 square miles and is without lakes at its upper headwaters, its water powers are of sufficient importance to have already attracted capital for their development. At the eastern limits of the city of Merrill a dam 200 feet long has been rebuilt so as to give a head of 21 feet. This dam is owned by the Prairie River Power and Boom Company. Nine miles northeast, in sec. 13, T. 32 N., R. 7 E., at a point where the river has worn a deep channel in the rocks, forming dalles, a masonry dam to furnish a head of 72 feet is now being built by the same company. This power is now transmitted electrically to the lower dam for use in a paper mill.

In sec. 14, T. 33 N., R. 8 E., are smaller dalles, where a head of 20 feet may be obtained.

EAU PLEINE RIVER.

This river has a narrower and smaller drainage area than either the Rib or the Eau Claire and is entirely devoid of lakes. Like the latter, it has considerable descent concentrated in its lower reaches, one power with a 15-foot head being located within 2 miles of its mouth. Following is a summary of its powers:

Dam-site locations on Eau Pleine River.

Location.	Head.*	Remarks.
	Feet	
Sec. 18, T. 26 N., R. 6 E.	15	Undeveloped
Sec. 24, T. 26 N., R. 6 E.	15	Do.
Sec. 13, T. 27 N., R. 3 E.	15	Do.
Sec. 4, T. 27 N., R. 3 E.	10±	Developed.
Sec. 24, T. 28 N., R. 2 E.	10±	.....

* Authority is D. L. Plummer, Surveyor.

EAU CLAIRE RIVER.

The Eau Claire River enters Wisconsin River from the eastern side, at a point only three miles below Wausau. While its drainage area, 423 square miles is much smaller than most of the tributaries its fall is concentrated so largely in its lower portion as to make it an important water power stream. For this reason, it was carefully surveyed during the winter 1895–6 for a distance of 24 miles above its mouth.

The valley has a sandy soil with some gravel for the lower 20 miles, and at one time supported valuable forests of pine. Even at the present time, the lumbering industry is a controlling factor on the river, all the existing dams being used, at present, for logging purposes only. At Scofield and Kelly, where saw-mills are located, water power was formerly used but has now been entirely replaced by steam.

There are a number of lakes at the headwaters of this river which could be use d as reserves to increase the low water flow of the river. No flow measurements of this river have been made, but, by comparison with similar adjacent regions, an ordinary low water flow of .50 second foot per square mile of drainage area could be expected.

*Fall in the River.**—An accurate profile of the river is given in the following table:

* Taken from the recent cooperative survey in charge of L. S. Smith.

Profile of the Eau Claire River. [*Wis. River tributary.*]

No.	Station.	Distance.		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1.	Mouth of river	0	0	1143	.....	.....
2.	Scofield, below dam	0.5	0.5	1153	10	20
	above dam	0.5	0.0	1161	8	.....
3.	Kelly, below dam	6.7	6.2	1178	17	2.7
	above dam	6.7	0.0	1190	12	.....
4.	Callon, below dam	9.8	3.1	1203.6	13.6	4.4
	above dam	9.8	0.0	1215	11.4	.....
5.	Backwater of dam	11.3	1.5	1216	1.0	0.6
6.	E. line sec. 18, T. 28, N. R., 8 E	14.0	2.7	1227.5	11.5	4.3
7.	Bridge. bet. T. 28 and T. 29..	16.3	2.3	1237.3	9.8	4.3
8.	Bridge. center S. 27, T. 29, R., 9 E.	18.3	2.0	1247.3	10.0	5.0
9.	Barnards Rapids, foot	19.8	1.5	1260.0	12.7	8.5
10.	Barnards Rapids, head	20.6	0.8	1280	20	25.0
11.	The Dalles, foot of	21.2	.6	1285	5	8.3
12.	W. line Sec. 7, T. 29, N, R., 10 E	22.2	1.0	1320	35	35
13.	The Dalles, head of	22.7	.5	1345	25	50
14.	SW. ¼ Sec. 8, T. 29, R., 10 foot dam	23.6	.9	1355.6	10.6	11.8
15.	SW. ¼ Sec. 8, T. 29, R., 10 head of dam	23.6	.0	1362.3	6.7	.....
16.	Jc. E. & W. Forks,*	36.0	12.4	1442.5	80.2	6.5

* Authority is the C. & NW. Ry. Chf. Engr.

The average slope of the river in the first 24 miles is 9.3 feet per mile. The total fall in this distance is 220 feet, of which 37 feet is at present developed at three dams, at Scofield, Kelly and Callon. Forty feet could be added to this by improvement of the dam, while at least an additional 100 feet could be developed by constructing three or more dams as described in the following.

Scofield Dam.—The first dam site is located one-half mile above the mouth of the river at the town of Scofield, a place of 600 population. A timber dam, 350 feet long, at this place maintains a head of eight feet. Both beds and banks are in the pre-Cambrian rock. By blasting out the rock below for a distance of 1,500 feet, this head could be increased to 14. The crest of dam could also be raised about two feet without flooding. A 16 foot dam at this point would be able to develop, at ordinary low water, 300 h. p., and for nine months in the year, at least 600 h. p. The power could be sold in Wausau, a city of 13,000 people only three miles distant. The charter rights of this dam are owned by the Brooks and Ross Lum-

ber Company. Scofield is on the Wisconsin Valley Division of the Chicago, Milwaukee & St. Paul Railway, and is also served by a spur of the Chicago & North Western Railway from Kelly.

Between the crest of the Scofield dam and the foot of the next dam above, the river has a fall of 17 feet, 10 feet of which could be cheaply developed near the line between Sections eight and nine, Township twenty-eight North, Range eight East. Such a dam would develop 150 theoretical h. p.

Kelly Dam.—The next dam is located about six miles by river, or three miles by railroad, from Scofield. About 500 feet above the highway bridge at Kelly, an old timber dam, 275 feet long, is located between rock banks, maintaining a head of 12 feet. By blasting a distance of about 300 feet, an increase in head of three feet could be secured. As the banks are high, the crest of the dam could be raised at least five feet more, giving a total head of 20 feet, which, at ordinary low water, would develop 400 theoretical h. p. The sawmill which is located immediately west of the highway bridge is served by spurs from both the Chicago & North Western and Chicago, Milwaukee & St. Paul railroads. John Manser, of Wausau, owns both dam and mill.

Callon Dam.—The next dam is located three miles above Kelly at Callon. This is a timber dam, in poor repair, about 200 feet long and maintaining a head of 12 feet. The bed and banks are in pre-Cambrian rock. By raising the crest of this dam ten feet and building a canal about 1,000 feet long, the head could be increased to 27 feet; equivalent, at ordinary low water, to about 500 theoretical h. p. This water power is near the Chicago & North Western Railway. Both the present dam site and the proposed canal site are owned by John Manser, of Wausau.

The next dam site is found at a point two miles above Callon, where a dam 10 feet high and a canal 2,500 feet long on the right bank would develop a head of 14 feet. A head of ten feet could be cheaply developed just above the highway bridge on the town line, between towns twenty-eight and twenty-nine.

Southwest Quarter Section Twenty-Seven, Township Twenty-Nine North, Range Nine East. Dam Site.—A dam 300 feet long could develop a head of 20 feet. The river narrows at this point to 200 feet and flows between high rocky banks. Such a dam would back the water to Barnard's Rapids, two miles up stream.

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Fig. 1. U. S. LEATHER COMPANY'S DAM, TOMAHAWK RIVER.

Fig. 2. THE DELLS OF THE EAU CLAIRE RIVER.
65 feet fall in 1.5 miles.

Barnard Rapids.—These rapids are located in the northeast quarter of section twenty-three, township twenty-nine north, range nine east. The dam site would be located near the east line of the above section. A dam 400 feet long and 18 feet high would develop a head of nearly 35 feet, 1,800 feet below such dam site. The canal would be constructed on the right bank. The rapids are 2,000 feet long in the pre-Cambrian rock, in which distance the river falls 15 feet. The drainage area above this point is 310 square miles, so that a 35 foot head would develop, at ordinary low water, about 300 theoretical horsepower. The Chicago & North-Western Railway is distant six miles from this site.

The Dells of the Eau Claire.—By far the greatest rapids on the river occurs at the dells, which are found in the northeast quarter of section twenty-three, the southeast of the southeast quarter of Section twelve, Township twenty-nine north, Range nine east, and in the south west quarter of Section seven, Township twenty-nine, Range 10 east. In a distance of one and one half miles, the river descends 65 feet in a series of leaps and rapids between steep walls of pre-Cambrian rock.

Most of this descent could be made available by two dams, one 22 feet high and 500 feet long in the northeast quarter of Section thirteen, Township twenty-nine north, Range nine east, at the foot of an island, producing a head of 30 feet, 1,000 feet below the dam site, and the other just above the highway bridge in the southwest quarter of Section seven, Township twenty-nine north, Range ten east. A good view of this dam site is shown in Plate XXXI. The latter dam would be 15 feet high and 400 feet long, with a canal on the right bank about 600 feet long. This would develop a head of 30 feet, equivalent to 500 theoretical horsepower at ordinary low water. This last power is owned by G. D. Jones, of Wausau, and L. L. Parks, of Watertown.

In the 13.3 miles between the junction of the east and west forks of the Eau Claire and the head of the Dalles, the river has a total fall of 97.5 feet, or an average of 7.3 feet per mile. The banks are high at frequent intervals, so that the greater part of the head could be developed when the surrounding country is sufficiently settled to make a market for the power.

Rib River.

Geology and Drainage.—The drainage area of Rib River is 498 square miles. The river rises in twelve small lakes, the largest of which, Rib Lake, has an elevation of 1,556 feet. The river reaches the Wisconsin below Wausau at an elevation of 1,145.8 feet, after a course of about 50 miles, giving it an average fall of about 8.2 feet per mile. Below Rib Falls the river occupies a filled or alluvial valley, while above that point the river channel as a rule is in the crystalline rock, with banks of clay or alluvial deposit.

The river is subject to great freshets which have made it very difficult and expensive to maintain dams except on the rock. Floods of 14 feet above low water are reported at the railroad crossing below Marathon.

Fall in the River.—The following table gives, with considerable detail, the fall of the river. From this it will be seen that in the lower or alluvial region the average slope of the river is about 3.3 feet per mile, while in the 11 miles above Rib Falls, the river has a natural fall of 15 feet per mile.

Profile of Rib River.

No.	Station.	Distance.		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of River	0.0	.....	1145.8	.....	.....
2	N. E. ¼, Sec. 2, T. 28, R. 6 E., C. & N. W. Ry.	8	8	1170.0	24.2	3
3	S. E. Corner, Sec. 6, T. 28, N. R. 6 E	12.5	4.5	1287	17	3.8
4	Rib Falls, below dam	18	5.5	1214	27	5
5	Rib Falls, above dam	18	.....	1228	14	.....
6	S. line, Sec. 30, T. 30 N, R. 5 E.	24	6	1250	22	3.7
7	S. line, Sec. 13, T. 30 N, R. 4 E.	26	2	1300	50	25
8	S. line, Sec. 3, T. 30 N, R. 4 E.	29	3	1380	80	26.7
9	S. line, Sec. 3, T. 31 N, R. 3 E.	37	8	1420	40	5
10	Rib Lake	48	11	1556	136	12.4

* Authority: No. 1, State Co-operative Survey; 2-9, United States Geological Survey Topographic Map; 10, Wisconsin Central Railway.

Water Powers.

Section Four, Township Twenty-eight North, Range Six East.—The United States Geological Survey map shows that in this section the river valley is very narrow so that it seems very probable that a head of 20 feet could be developed by a comparatively short dam. This site is about two miles east of Marathon.

Rib Falls.—Although the river falls five feet per mile between Rib Falls and the above dam site, the river in this stretch has too low banks for a dam. At Rib Falls, however, the valley is narrow, and here is located the dam of the Baesemann Manufacturing Company, with a head of 14 feet. One 60 inch and one 28 inch turbines, rated at 135 horsepower, are used in the summer months only to run a saw, shingle and planing mill. Besides these turbines, two 28 inch and one 22 inch turbines, rated at 80 horsepower, are used to run a flour and feed mill, working 12 hours per day during the summer and 24 hours per day during the winter time.

This is the only dam now maintained on the river. The drainage area above Rib Falls is about 290 square miles. Black Creek joins the main river just above this dam site.

Northwest Quarter of Section Eight, Township Twenty-nine North, Range Five East.—At this point the valley narrows again giving opportunity of developing a head of about 15 feet at reasonable expense.

Northwest Quarter of Section Thirty-one, Township Thirty North, Range Five East.—About 2,000 feet below the north line of this section, the banks are very steep and high enough to develop a head of about 30 to 40 feet.

Section Thirteen, Township Thirty North, Range Four East.—A similar dam site to that just described above is found near the south line of Section thirteen, and at least 20 foot head could be easily developed. Indeed, there are numerous dam sites in the river above this point, but the river is, of course, small.

The principal tributaries of the Rib River are the Little Rib, with a drainage area of 75 square miles and which joins the river about three miles from the Wisconsin River, Black Creek, with a drainage area of about 85 square miles, and Scott Creek, with an area of 50 square miles. Though all have a steep gradient, the amount of water in each is small, especially in the late summer and the mid winter.

Big Eau Pleine River.

Geology and Drainage.—This river, the Indian name of which means "full river," has a total drainage area of 377 square miles.

The geology and drainage features are very similar to those of its larger neighbor, Rib River, except that a larger proportion of its channel is in an alluvial valley of even a flatter gradient than that of Rib River.

Fall in the River.—Like Rib River, the important rapids are too far from the mouth of the river to be of much value as power producers. In the first 24 miles above its mouth its average fall is only 2.2 feet per mile. At March and Cherokee Rapids, however, the gradient is 8 and 16 feet per mile, respectively.

The following table gives all the available information regarding the fall.

Profile of Eau Pleine River.

No.	Station.	Distances.		Elevation above the sea.	Descent Between Points.	
		Distance from mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	00.0	.....	1,100	.....	.....
2	Stratford	24.5	24.5	1,155	55	2.2
3	March Rapids	30.0	5.5	1,200	45	8.0
4	Cherokee Rapids, foot of	34.0	4.0	1,220	20	5.0
5	Cherokee Rapids, head N. line Sec. 14, T. 28 N., R. 2 E.	37.7	3.7	1,280	60	16.2

Authority: 1, Cooperative Survey; 2, Chicago & Northwestern Railway; 3 to 5, United States Geological Survey Topographic Map.

WATER POWER SITES.

Center of Section 21, Township 27 North, Range 4 East.—Two miles east of the Stratford, the bed of the river is in pre-Cambrian rock and the river flows between high and narrow banks. A dam here would easily develop a head of between 15 and 20 feet. The drainage area above this point is 250 square miles.

2. *Center of Section 13, Township 27 North, Range 3 East.*—Conditions are here favorable for a dam with a head of at least 10 feet.

3. *March Rapids.*—The river is here flowing in the hard crystalline rocks. Near the center of Section 3, Township 27, north, Range

3 east, the conditions, as shown by the United States Geological Survey Topographic Map, are very favorable for a dam 15 to 20 feet high.

4. *Cherokee Rapids.*—These rapids extend in the hard rock for a distance of about three miles in which distance there is a fall of 60 feet. It would take careful survey to determine the best place for a dam but an inspection of the topographic map would indicate that two dams would develop the greater part of this fall. The drainage area above this point, however, is only 180 square miles.

Plover River.

Geology and Drainage.—Plover River is the last tributary of Wisconsin River, of even secondary importance, to join the parent stream from the left bank. For the last mile of its course, that is, from the dam at McDill to the mouth of the river, the river channel is in the pre-Cambrian rocks, and also six miles above at Jordan (Hull post-office), the pre-Cambrian rocks again outcrop, but between these two points, and except for a few short intervals above Jordan, the river occupies a drift filled or alluvial filled valley. The soil is chiefly a sandy loam.

The drainage area of the river, about 195 square miles, has a length of over 40 miles and an average width of less than 5 miles. The fact that a large share of its fall is concentrated in its lower reaches gives the river its only merit as a water power stream.

Fall in the River.—Between the Chicago and North-Western bridge and Hatley, and the mouth of the river (a distance of about 36 miles) the river has a fall of 212 feet or an average of nearly 6 feet per mile. Originally there was a fall of about 61 feet in the last 8 miles of its length but the building of the Plover Paper Company dam on the Wisconsin River, just below the mouth of Plover River reduced the fall, by about 9 feet.

The following profile gives detail information of the fall of the river.

Profile of Plover River.[1]

No.	Station.	Distance.		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	0	0	1,044	.....	.....
2	McDill dam, foot of	1	1	1,047.2	3.2	3.2
3	McDill dam, crest of	.....	.....	1,055.6	8.4	.....
4	Wis. Cent. Bridge, S. 34, T. 24, N. 8 E.	2.5	1.5	1,063.0	7.4	5.0
5	Jordan's dam, foot of	8.0	5.5	1,084.6	21.6	4.0
6	Jordan's dam, crest of	.....	.....	1,106.6	22.0	.....
7	S. E. cor. Sec. 5, T. 26, N. R. 9 E.	22.5	14.5	1,166.0	53.4	3.
8	Bevent, Sec. 34, T. 26, N. R. 9 E.	24.7	2.2	1,188	23	3.7
9	N. E. S. W. Sec. 23, T. 26, N. R. 9 E.	28.2	3.5	1,200	17	5
10	Hatley, C. & N. W. Ry. Bridge	35.7	7.5	1,256	56	7.4

[1] Authority; 1 to 6. Levels run in 1906 by Geo. Gross under the direction of L. S. Smith. 7 to 9 inclusive U. S. G. S. 10, C. & N. W. Ry.

WATER POWER.

McDill Dam.—The Wisconsin Graphite Company of Pittsburg, Pa., maintains a timber dam about one mile from the mouth. The dam is capable of developing a head of 16 feet but the average head is only 10 feet. The mill pond is about 1.5 miles long. The company have installed 2, 40-inch "Trump" turbines rated at 290 horsepower. The grinding mill runs from 12 to 24 hours per day and uses no steam power. F. R. Sellers of Stevens Point is the western manager of this company.

Jordan Dam.—Formerly the owners of this dam maintained 3 old turbines under a 14 foot head rated at 455 horsepower and used the power for a grist mill. In 1904 the mill was sold to William and Sinclair Mainland of Oshkosh who caused the upper dam to be raised 3 feet and a canal 800 feet long dug which then developed a head of 23 feet. One pair of 35-inch Leffel Sampson horizontal turbines are installed and develop 580 horsepower. This power is conducted electrically to Stevens Point and there used for lighting and power. The dam is 50 feet long and is built on the pre-Cambrian rock.

Section 1, Township 24 North, Range 8 East.—One mile above Jordan the pre-Cambrian rock outcrops again in the N. E. ¼ of S. E. ¼, Section 1, giving rise to rapids.

During the summer of 1906 a masonry dam was constructed at this point with a head of twelve feet. The developed power is 100 horsepower. The power is owned by Arthur Van Orden, Stevens Point, Wisconsin, R. D. No. 2.

Section 7, Township 25 North, Range 9 East.—A terminal moraine in the S. E. ¼ of section 7 gives rise to rapids which have been developed by a dam owned by S. Y. Bentley, Stevens Point, with a head of about 12 feet. The power is used to run a saw mill.

Undeveloped Power.—Of the 212 feet fall in the river, between its mouth and Hatley, only about one-quarter is as yet developed. Between the foot of Jordan dam and the backwater of the McDill dam is a fall of 29 feet.

It seems likely that a careful survey of this part of the river would discover a dam site which would allow of a dam with a head of 10 to 15 feet.

When a demand for power justifies the expense, dams with moderate heads will probably be built at Bevent as well as two or three miles above and below it.

Yellow River.

(Wisconsin River Tributary.)

Drainage and Geology.—In point of size of drainage area, 946 square miles, Yellow River is the most important tributary of the Wisconsin River, but unfortunately, its fall is not commensurate with its size. Only in the upper third of its course, where it runs in the crystalline rocks, are its falls and rapids considerable. In the 44 miles below Dexterville, its fall averages 2.5 feet per mile. In its middle portion, the river and tributaries traverse a marshy soil while its lower third occupies a sandy valley with low banks.

The following table gives some details of its fall:

Profile of Yellow River.

No.	Station.	Distance.		Elevation above sea.	Fall Between Stations.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	0.0	.....	858	.....	.....
2	Necedah, Sec. T. R.....	13	13	895	37	2.8
3	One mile west of Babcock	37	24	957	62	2.6
4	West of Dexterfield	44	7	973	16	2.3
5	West of Marshfield, Sec. 9, T. 25, N., R. 2 E.....	71	27	1,146	173	6.4

[1] Authority, 2-5, Railroad elevations.

WATER POWERS ON THE YELLOW RIVER.

The water powers of this river have not received the attention which their importance deserves. An average fall of 2.5 feet per mile in the lower third of its length should insure a considerable number of horsepower, although on account of the low sandy banks, the height of the dams must be limited to about 10 feet.

Germantown Dam.—At the mouth of the Yellow River, the banks are high enough to develop a head of nearly 20 feet, although in time of high water this head would be greatly reduced. High water in the Wisconsin River is about 10 feet above the ordinary stage.

A dam has been maintained near the mouth at a little village called Germantown. The ordinary low water flow of the river may be figured at about 400 second feet, so that a 10 foot head would equal 440 theoretical horsepower.

Necedah.—The only dam used for power on this river is located at Necedah. The owner, F. M. Reed, has installed turbines rated at 210 horsepower, under a 10 foot head, all used to run a flour mill. The head of this dam could be increased to 12 feet, equal to about 450 horsepower.

Babcock Power.—Chapter 142, Laws of 1891, granted a charter to Henry C. Paine for a dam located at Babcock in Township twenty-one north, Range three east. It seems probable that a good power could be developed at this point at a reasonable expense, but as yet no construction has been attempted.

Pittsville Power.—A charter was granted in 1879 to Carl B. and A. E. Long for a dam to be located in Section thirty-four, Township

twenty-three north, Range three east, but no construction has as yet been attempted. The bed of the river is here in the hard crystalline rock, causing important rapids.

Rapids in Section Twenty-two, Township Twenty-three north, Range Three East.—About two miles north of Pittsville, the crystalline rock again crops out in both bed and banks of the river. It is estimated that there is a total fall of at least 30 feet in the two miles of rapids.[1]

Big Bull Falls.—This includes rapids of over 30 feet fall located in Section twenty-eight, twenty and twenty-one, Township twenty north, Range three east. In fact the entire upper reach of the river is characterized by numerous rapids, but the drainage area is here small.

Lemonweir River.

Geology and Drainage.—The drainage basin of this river includes 590 square miles, none of which is within the pre-Cambrian region As a result the river has a lower gradient than that of its neighbor, the Yellow River, and more like that of the Wisconsin River opposite.

The extreme upper branches of the river traverse a swampy region while the remainder of the river is in the Potsdam region, both conditions being favorable to a uniform flow.

Fall of the River.—The fall of the river is devoid of any concentrations. Between the Chicago, Milwaukee and St. Paul crossing, north of Valley Junction, and its mouth, the average fall is only 1.75 feet per mile. The following table gives all known data regarding the fall in the river.

Profile of the Lemonweir River.[2]

No.	Station.	Distances.		Elevation above the sea.	Fall Between Sections.	
		From mouth.	Between points.		Total.	Per Mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	0.	0.	834	.....	.....
2	Lemonwier dam { Below	11.	11.	852	18.	1.6
	Lemonwier dam { Above	11.	0.	858	.....	.....
3	Mauston dam { Below	15.5	4.5	859	1.0	0.2
	Mauston dam { Above	15.5	0.	866	.....	.....
4	Near New Lisbon	25.	9.5	866	11.	1.0
5	Necedah Junction, below dam	42.5	.....	.....	.....	.....
6	Necedah Junction, above dam	42.5	17.5	...	.....	.....
7	One mile north of Valley Junction	47.0	4.5	915	.....	.....

[1] Authority State Geologist, S. Weidman.
[2] Authority 1-3, L. S. Smith, 4-7, C. M. & St. P. R. R.

WATER POWERS.

Lemonweir.—The first dam is located at Lemonweir about 11 miles above the mouth of the river. A feed mill owned by R. Davis is located at this point with a turbine under an average head of 6 feet.

Mauston Dam.—The second dam is located at Mauston 15 miles from the mouth of the river. The drainage area of the river above this point is 560 square miles. The river banks are only sufficiently high to develop a head of 8½ feet. The dam was recently reconstructed having been washed out by a severe freshet. The Mauston Electric Service Company recently purchased this power and have installed 3 new 49-inch turbines rated at 210 horsepower. This power is used to run a flour and grist mill during the day and an electric light plant at night. The company have installed also 150 horsepower of auxiliary steam power.

New Lisbon Dam.—Two turbines are here installed under a head of 10 feet and rated at 100 horsepower. The owners report the wheels old and that they intend to replace them by new wheels soon. At times of high water the head is reduced to 4 feet. The drainage area above New Lisbon is about 500 square miles.

Baraboo River.

Geology and Drainage.—Few, if any, of the tributaries of the Wisconsin River are more fully developed than the Baraboo, and only three tributaries have a larger drainage area (655 square miles). The river has a total fall of 154.5 feet in a distance of 75 miles, and, as the river flows through a rich agricultural region, its many powers are generally utilized.

The river occupies an old river valley which is deeply filled with alluvium. At Ablemans, this filling is reported at 70 feet, while at other places the filling is several times this. At Reedsburg and above in the valley of the upper Baraboo, the immediate valley is narrow and sandstone is frequently exposed in both bed and bank of the river. This sandstone, while usually soft and friable, sometimes occurs in firm quarry layers. The ground on both sides of the valley rises to 200 or 300 feet.

A glacial moraine is crossed at Baraboo, whcih gave rise in a state of nature to boulder rapids with a total fall of nearly 50 feet. About five miles below Baraboo, the river strikes the northern one of the two eastward trending quartzite ranges, referred to before as the Baraboo ranges, penetrates it, and, after flowing in the intervening valley for 15 miles, once more passes through the northern range, and then enters the plain of the Wisconsin valley near Portage. Because of the steep slopes of the Baraboo valley and its state of cultivation, the rainfall reaches the river very promptly, giving rise to sudden freshets and extreme low water.

Profile.—The following table, compiled largely from railroad data, gives a fairly complete profile of the river from source to mouth.

Railroad Facilities.—The Chicago and North-Western Railway follows the river closely from Baraboo to the headwaters of the river, crossing it frequently and providing good transportation facilities.

WATER POWERS.

The water powers of this river will be described in order from mouth to the source.

In the last 15 miles of its course, the banks of this river are too low to allow of any considerable development, but at the point where the river breaks through the Baraboo Bluffs, the banks are high and rock abundant. Many years ago a dam was maintained at this place, but, for unknown reasons, it was abandoned long ago.

Baraboo Powers.—The drainage area above Baraboo is 550 square miles. By far the most important concentration of fall originally existed at Baraboo in the form of boulder rapids. These rapids, with a total fall of nearly 50 feet, have been fully improved by four dams, the lowest one of which is

The Linen Mill Dam.—This is a plank dam with an average head of five feet, built in 1902 and owned by George McArthur. One 60 and one 30 inch turbine are installed, rated at 30 horsepower and used to run a mill for the manufacture of Turkish towels and crashes. At the time of spring freshets, the water backs up so as to destroy the head. Between the crest of this dam and the tail race of the next power above, is a fall of two feet.

City Water Works Dam.—This is a rock filled dam located on the east line of the northeast quarter of the northwest quarter of section

Profile of Baraboo River.

No.	Station.	Distance.		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	Mouth of river	0.0	0.0	783	.....	.....
2	Linen mill dam, below	24.0	24.0	796.7	13.7	0.6
3	Linen mill dam, above	.....	.....	801.7	5.0	.....
4	Baraboo water work, tailrace	25.0	1.0	803.7	2.0	2.0
5	Baraboo waterworks dam, crest	25.5	.5	816.3	12.6	.....
6	Oak street dam, below	26.2	.7	817.6	1.3	.....
7	Oak street dam, crest	.....	.....	823.8	6.2	.....
	Island Woolen Mills dam:					
8	below tailrace	26.7	.5	826.3	2.5	.....
9	crest of dam	.....	.....	842.9	16.6	.....
10	N. E. ¼, Sec. 1, T. 11 N, R. 5 E.	33.7	7.0	845.0	2.1	0.3
11	N. W. ¼, Sec. 2, T. 11 N, R. 5 E.	36.4	2.7	845.9	.9	0.3
12	S. W. ¼, Sec. 34, T. 12 N, R. 5 E.	38.4	2	846.4	.5	0.3
13	West line Sec. 28, T. 12 N, R. 5 E.	42.1	3.7	852.4 L. W.	6.0	1.6
14	At Reedsburg, below dam	47.7	5.6	864.	11.6	2.0
15	At Reedsburg, above dam	.....	7.2	871.2 H. W.	.....	.....
16	E. of La Valle, Sec. 33, T. 13 N, R. 3 E.	52.5	4.8	875.0	3.8	0.8
17	E. of La Valle, Sec. 23, T. 13 N, R. 3 E.	55.0	2.5	878.	3	1.2
18	La Valle dam, tailrace	57.5	2.5	.....	.....	.....
19	La Valle dam, crest	.....	.....	.....	.....	.....
20	W. of La Valle, Sec. 20, T. 13 N, R. 3 W.	59.5	2.0	890.0	.....	.....
21	W. of La Valle, Sec. 17, T. 13 N, R. 3 W.	60.5	1.0	891.0	1	1.0
22	W. of La Valle, Sec. 6, T. 13 N, 3 W.	63.0	2.5	894.0	3	1.2
23	Wonewoc dam, tailrace	64.5	1.5	901.0	14	9.9
24	Wonewoc dam, crest of	.....	.....	908.0	7	.....
25	East of Elroy, Sec. 4, T. 14 N. R. 2 E.	75	10.5	937.5	29.5	2.8

*Authority 3-10. Levels by Wm. Kachel under direction of L. S. Smith. 11-25. Chief Engineer C. M. & St. P. Ry., run in November, 1898.

one near the city limits of Baraboo at the head of a long bend of the river. The water is conducted in by a canal 2,000 feet long to the power plant owned, like the dam, by the city of Baraboo. The power estimated at 150 horsepower is developed by one 45 and one 48-inch turbine under a 12.6 foot head.

The Manchester Roller Mill, owned by James Hull, has first right, by contract with the city, to the low water flow, and uses 80 horsepower for which they pay a rent of $600 per year to the city. The city has also installed steam power to the amount of 100 horsepower.

Hoyt Mill Company Dam.—This dam is located near the center of the city of Baraboo, about 4,000 feet above the dam just described. This is a rock filled dam, seven feet high and 200 feet long, built in very recent years. Formerly this dam developed a head of 10 feet and was used to run a flour mill on the left bank and a machine shop on the right bank, but both have been burned down. The power, which is estimated at 120 horsepower, is now for sale.

Island Woolen Company Dam.—This is the fourth and last of the dams in or near the city of Baraboo. It is owned by E. P. and W. H. McFetridge, who have installed one 45 and one 16-inch turbine under an average head of 17½ feet rated at 215 horsepower. The smaller turbine is used for electric lighting the mill while the larger wheel is used in the manufacture of Cassimeres. This company have also purchased a dam with a head of about six feet, located a short distance above this dam. No use of it is made, however.

Reedsburg Dam.—In the 21 miles of river between Reedsburg and Baraboo, the river has a total fall of only 30 feet. In the entire distance, the river has a very sinuous course, and, with the exception of a short distance at Ablemans, the banks are low and devoid of rock. At Reedsburg, however, the sandstone outcrops in both bed and bank of river, causing rapids. At this point a timber dam has been constructed with a head which varies between 10 and 4 feet, with an average of seven feet, and furnishes power to both a woolen and flour mill. The drainage area above Reedsburg is 380 square miles.

The woolen mill, called the "Reedsburg Mill," is owned by the Appleton Woolen Mill Company and manufactures fancy woolen goods. The company have installed one 60-inch and one 56-inch

turbine rated at about 70 horsepower. They have installed, also, auxiliary steam power of 125 horsepower. The company are entitled, by deed, to enough water to run a "four set woolen mill."

The Reedsburg grist mill has two turbines of about the same size as the woolen mill, but an older type. They are entitled to the remainder of the power. This mill is owned by J. Heaton, who has also installed auxiliary steam power.

La Valle Dam.—This dam develops a head of eight feet and is used to run the La Valle Roller Mill. The owner, H. E. Paddock, reports that plenty of power is available for eleven months in the year. The drainage area above La Valle is 230 square miles.

Wonewoc Dam.—This is a timber dam and develops an average head of seven feet. One 48-inch and one 36-inch turbine are installed and furnish power for a flour and feed mill owned by W. H. Funk. The head varies between six and nine feet. No steam power is used. Drainage area above Wonewoc is 180 square miles.

Elroy Dam.—This is the last dam on the Baraboo. Two 35-inch and two 30-inch turbines are installed under an average head of eight feet and used to run a flour and feed mill owned by R. M. DeLong and Company. The mill also has a 25 horsepower steam engine for use in time of low water.

Water powers on Tributaries of Baraboo River.

Name of tributary.	Location of dam.	Head of dam.	Rated H. P.	Purpose.	Owner.
Little Baraboo	Cazenovia	16	60	Flour and feed	Wm. Wall.
" "	Ironton	11½	95	Grist mill	F. Byrne.
" "	Sec. 5, T. 12, R. 3 E	8	.....	Not developed	
" "	Hillsboro	15	70	Flour and feed	Hillsboro Milling Co.
" "	Union Center	.....	.....	Undeveloped	
Leanabro Creek	Sec. 36, T. 12, R. 7 E.	29	18	Flour and lumber	H. L. Konkle Jr.
" "	At mouth of river	10-15	.....	Undeveloped	
Lorrendal Creek	Sec. 26, T. 11, N. R. 7, E	17	32	Flour	C. Falkenstenn.

Kickapoo River.

Geology and Drainage.—This river enjoys the distinction of having the largest drainage area (800 square miles) of all the Wisconsin River tributaries. It is also the last large tributary to join the parent stream, the point of junction being only 18 miles from the mouth of the Wisconsin. The entire basin is situated in the driftless area of Wisconsin. The rivers have deeply eroded their valleys.

The sides of the valleys are steep, the side hills frequently showing the sandstone structure with the usual limestone capping. The river is subject to high floods.

Fall in the River.—The great age of this river has resulted in wearing its channel down to a very low gradient. The average gradient in the 70 miles between La Farge and the mouth of the river is 2 feet to the mile, while, in the lower half of this distance, its gradient is only 1.5 feet per mile, the same as that of the lower reaches of the Wisconsin River.

The following profile is compiled from the railroad elevations and gives a good idea of the water power possibilities.

Profile of Kickapoo River.

	Distance.		Elevation above the sea.	Descent Between Stations.	
	From mouth.	Between points.		Total.	Per mile.
Mouth of river	0.0	.....	633.0	.....	.....
Sec. 7, T. 7 N., R. 4 W.	6.0	6	640	7	1.1
Bridge at Steuben	19.0	13	658.6	18.6	1.4
Bridge at Barnum	23.8	4.8	672	13.4	2.8
South of Gay's Mills	34.8	11	688	16	1.4
S. line Sec. 25, T. 11 N, R. 4 W.	46.6	11.8	710	22.0	1.9
N. E. S. W. Sec. 19, T. 11, R. 3 W.	50.1	3.5	716	6	1.9
Readstown	52.2	3.1	720	4	1.9
S. E. ¼ Sec. 33, T. 12 N., R. 3 W.	55.7	2.5	728.0	8	3.2
N. line Sec. 25, T. 12 N., R. 3 W.	60.0	5.3	735	7	1.3
Viola	62.5	2.5	745	10	4.0
La Farge	70.0	7.5	777	32	4.3

Authority: Chicago, Milwaukee & St. Paul Railway.

WATER POWER.

Gays Mills.—The first dam on the river is located at Gays Mills 35 miles (by river) from its mouth. The fall in this distance is 55 feet.

This dam owned by Atwood and Haggerty is built on the solid rock. The owners have installed two 40-inch turbines under a head of 6½ feet and rated at 80 horsepower. They claim that they use only one-third of the water in the river. This use includes the grinding of flour and feed, and furnishing power to an electric light plant. The drainage area above this point is 500 square miles.

Soldiers Grove Dam.—Atley Peterson, the owner of this dam, has installed two turbines under a head of 7 feet and rated at 120 horsepower. This power is used to manufacture hardwood lumber, and to run a municipal electric light and water-works plant. The owner has also installed 55 horsepower steam power. They report having had trouble to maintain their dam, owing to the absence of rock for a foundation.

Readstown Dam.—A dam is here maintained by Henika and Folwell with a head of 4 feet. The owners report that they have installed one 46-inch turbine rated at 30 horsepower. The power is used to run a feed mill and a saw mill.

Viola Dam.—A dam owned by E. R. Cushman develops a head of 6 feet. Five 48-inch turbines rated at 100 horsepower are used to run a saw and flour mill.

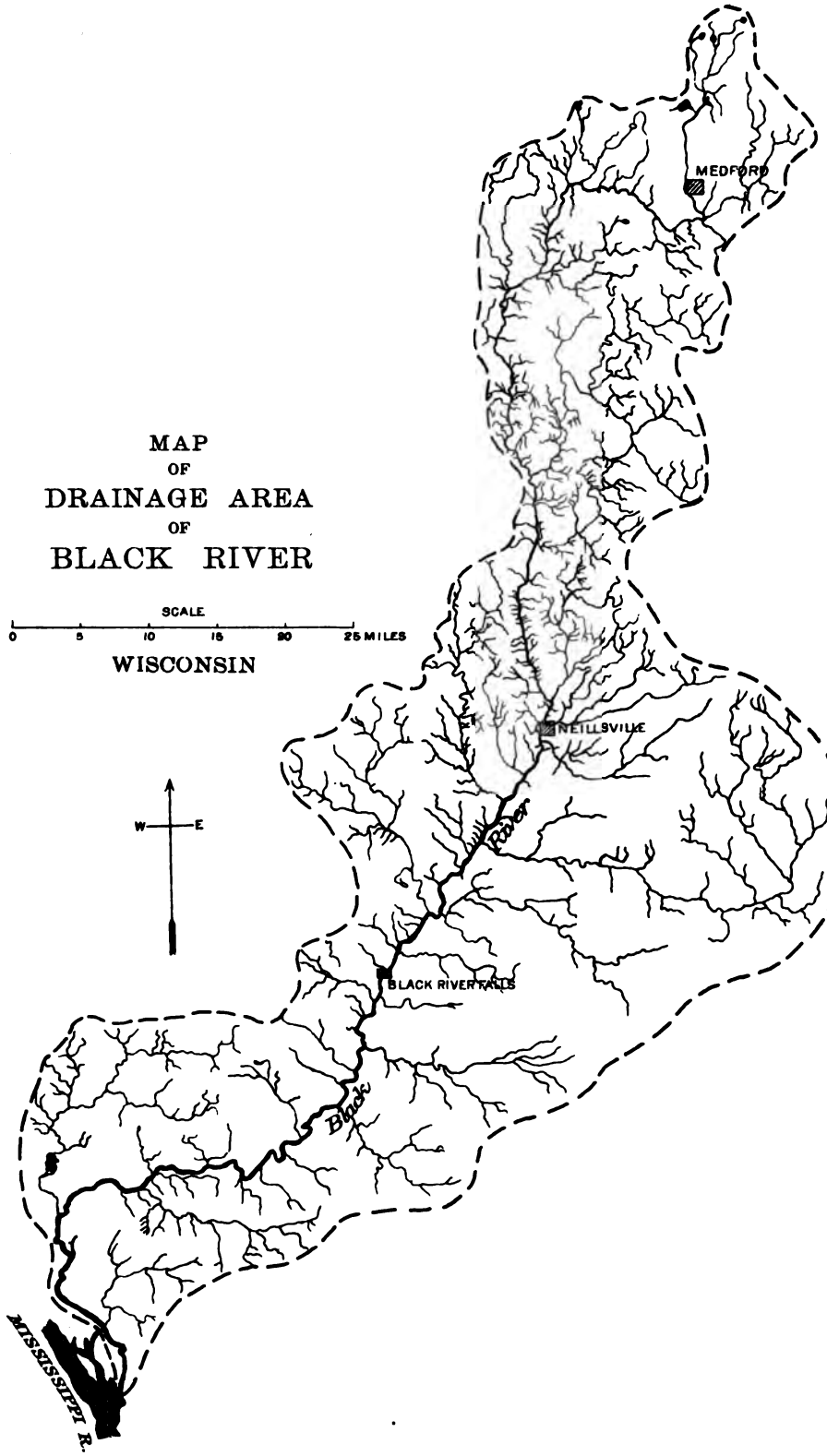
La Farge Dam.—The La Farge Milling Company maintains an 8 foot dam built on natural rock foundation. Three turbines 56, 40, and 35 inches in diameter rated at 160 horsepower are used in the day time to run a flour mill, and during the night to run the local electric light plant. The owners report that they can count on only 125 horsepower.

Rockton Dam.—This dam is owned by Bennett and Widmer. They have installed 3 turbines under a head of 7 feet and rated at 100 horsepower, all used in the manufacture of flour.

Mr. V. S. Bennett reports that he owns two undeveloped powers. One is located in Section 26, Township 14 north, Range 2 west, on the Kickapoo, which would develop a head of 10 feet with a 9 foot dam, and one power site, located in Section 35, Township 14, Range 2 west, on Warner Creek, where a 20 foot head could be developed by a 16 foot dam.

Small powers on Kickapoo River Tributaries.

River.	Location.	Owner.	Head	Turbine, H. P.	Use.
West Fork Kickapoo.	Bloomingdale	Dam washed out	.....	.....	Formerly was used as saw and grist mills
West Fork Kickapoo.	Avalanch	Avalanch Woolen Mill ..	..	15	Woolen mills.
Kickapoo	Ontario	E. W. Sanded	8	60	Saw and grist mills.
Kickapoo	One mi. N. of Ontario	Hiram Zimmerman	.....	50	Bridge factory.
Tainters Creek	Towerville ..	G. W. Davis	10	12	Manuf. yarn.
Tainters Creek	Towerville ..	C. H. Stemkard.	13	17	Flour mill.


MAP
OF
DRAINAGE AREA
OF
BLACK RIVER
SCALE
0 5 10 15 20 25 MILES
WISCONSIN
W
E
MEDFORD
NEILLSVILLE
BLACK RIVER FALLS
Black River
MISSISSIPPI R.

BLACK RIVER.

In order to point out the power possibilities along Black River a survey was made during 1906 from Black River Falls to Wisconsin Central Railway crossing near Withee. From the data collected on this survey sheets have been prepared showing a profile of the water surface, a plan of the river, contour along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets and may be had upon application to the Director of the U. S. Geological Survey.

Geology.—All that portion of the river from Black River Falls northward, is in the hard pre-Cambrian rock. For a large share of this stretch the river has worn deeply into the rock and banks that rise abruptly 40 to 60 feet, often with nearly vertical walls. In places, however, the rock is covered by the glacial deposits.

In the 55 miles between Black River Falls and its mouth, the river flows in the Potsdam sandstone region, but even here the average slope is 2.2 feet per mile. The valleys, however, are wide and the banks usually low, making the development of water power expensive, and more difficult of maintenance.

Rainfall.—A study of rainfall records given in the following figure will show that average annual rainfall on the drainage area of this river between the years of 1893 and 1905 was 31.84 inches. This was distributed among the three important periods as follows: Storage period 12.15 inches, growing period 9.57 inches and replenishing period 8.41 inches.[1]

[1] The storage period includes the 6 months from December to May inclusive, the growing period, June, July and August, and the replenishing period, September, October and November.

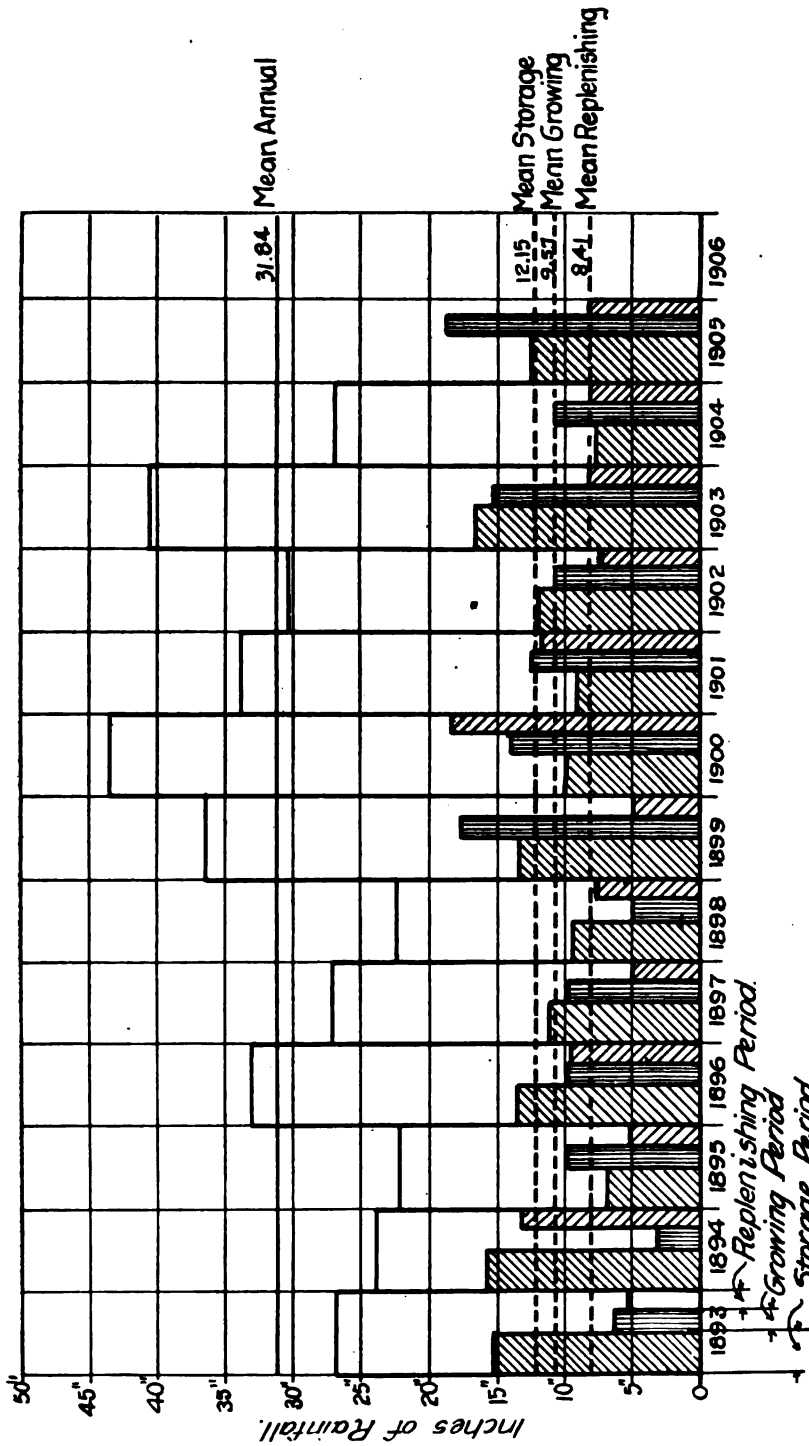


Fig. 9.—Rainfall on the watershed of Black River above Black River Falls.

Topography and Drainage.

Black River, hemmed in by the Chippewa on the west and the Wisconsin on the east, is restricted to a long and narrow watershed of about 2,270 square miles,[1] with an average width of only 20 miles. At one point the branches of Chippewa River extend to within a quarter of a mile of Black River. Like the Chippewa, about a third of the Black River drainage area is in the comparatively level sandstone region, so that the maximum watershed available for water powers, namely, at Black River Falls, is only 1,570 square miles.[1] The watershed narrows rapidly as the river is ascended, and at Neillsville, 22 miles in an air line from Black River Falls, the drainage area is reduced to only 729 square miles.[1] Were it not for this small watershed, the steep gradient of the river and its high, rocky banks would insure large water powers. Black River rises at an elevation of about 1,400 feet above sea level, and after a sinuous course of over 140 miles joins Mississippi River at La Crosse. The total descent in this distance is 772 feet, with details as shown in the following table:

Profile of Black River from its mouth near La Crosse to near Withee.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
1	La Crosse (near)	.....	.....	628	.....	.....
2	Black River Falls:					
	Below dam	55.0	55.0	749	121	2.2
3	Above dam	55.0	.0	763	14	.....
4	Chicago, St. Paul, Minneapolis and Omaha Railroad bridge	58.0	3.0	766	3	1.0
5	Halls Creek, mouth of	61.6	3.6	776	10	2.8
6	Halycon	67.0	5.4	793	17	3.1
7	Hatfield R. R. Bridge	71.2	4.2	838	45	10.4
8	East Forks, mouth of	74.2	3.0	846	8	2.7
9	Dells dam, below	77.5	2.3	874	28	8.5
10	Wedges Creek, mouth of	78.5	1.0	893	19	19.0
11	Cunningham Creek, mouth of	84.8	6.3	909	16	2.5
12	Center sec. 22, T. 24 N., R. 2 W	86.8	2.0	929	20	10.0
13	O'Neill Creek, Neillsville	90.8	4.0	989	60	15.0
14	Bridge, secs. 9 and 16, T. 25 N., R. 2 W	98.8	8.0	1,034	45	5.6
15	Bridge, secs. 21 and 28, T. 27 N., R. 2 W	103.5	4.7	1,070	36	7.9

[1] Census report, vol. 17, 1880, p. 87

Profile of Black River from its mouth near La Crosse to near Withee.—Con.

No.	Station.	Distance.		Elevation above sea.	Descent Between Points.	
		From mouth.	Between points.			
		Miles.	*Miles.*	*Feet.*	*Total fall, feet.*	*Per cent.*
16	Bridge, Fairchild and Northeastern Rwy.	107.8	4.3	1,094	24	5.6
17	Site New Greenwood dam	109.3	1.5	1,105	11	7.3
18	Between secs. 27 and 28, T. 27 N., R. 2 W.	110.3	1.0	1,107	2	2.0
19	Hemlock dam, 600 feet below.	113.5	3.2	1,132	25	8.0
20	Hemlock dam, above	113.6	.1	1,151	19	.....
21	Bridge, secs, 20 and 29, T. 29 N., R. 2 W.	119.6	6.0	1,167	16	2.7
22	Bridge, Wisconsin Central Rwy., west of Withee	125.1	5.5	1,187	20	3.6
23	Bridge, Wisconsin Central Rwy., Duluth Br.	131.7	6.6	1,198	11	1.7

Authority: No. 1 (low-water elevation), Mississippi River Commission; 2 to 22, Joint Survey of Wis. Geol. and Nat. Hist. Survey and United States Geological Survey.

The United States Geological Survey maintained a gaging station on Black River at Melrose for nine months in 1903, but as the station proved unsatisfactory it was abandoned August 1, 1903. Such measurements and observations as were taken are given below:

Discharge measurements of Black River near Melrose, Wis., in 1903.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Second-feet.*
January 15	L. R. Stockman	4.30	[1]598
February 7	" "	4.30	[1]508
April 4	" "	5.90	2,982
May 1	" "	11.00	10,931
June 13	" "	3.90	842

[1] Frozen.

Mean daily gage height in feet, of Black River near Melrose, Wis., December 4, 1902, to August 1, 1903.

Day.	1902.	1903.							
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	5.05	4.10	4.30	5.10	11.00	7.60	3.60	3.75
2	.....	5.00	4.10	4.35	4.85	10.00	.....	6.70	.....
3	.....	4.90	4.10	4.40	5.30	10.25	.....	11.20	.....
4	3.75	4.75	4.10	4.45	5.65	10.50	.....	10.90	.....
5	3.95	4.60	4.10	4.60	5.90	9.65	6.00	13.00	.....
6	4.00	4.60	4.20	4.75	6.50	9.05	4.70	12.30	.....
7	3.80	4.50	4.20	(1)	6.65	8.15	4.40	10.20	.....
8	4.35	4.50	4.20	6.25	6.50	7.00	4.30	7.90	.....
9	4.35	(1)	4.20	8.20	6.20	6.95	4.25	6.90	.....
10	4.30	4.40	4.20	9.30	5.50	6.55	4.00	7.40	.....
11	4.35	4.40	4.30	9.70	5.60	6.10	4.00	8.70	.....
12	4.20	4.40	4.25	10.75	.....	6.65	3.95	7.20	.....
13	4.20	4.40	4.20	12.05	5.45	10.60	3.95	6.70	.....
14	4.10	4.40	4.20	12.55	5.60	12.00	3.80	6.20	.....
15	4.15	(1)	4.20	11.55	5.95	10.90	3.80	5.80	.....
16	4.10	4.30	4.10	9.85	5.85	9.15	3.80	5.30	.....
17	4.00	4.30	4.15	9.40	6.05	7.80	3.70	4.50	.....
18	4.00	4.30	4.00	10.35	5.60	6.55	3.70	4.20	.....
19	4.05	4.30	3.95	11.95	5.00	6.50	3.70	4.10	.....
20	4.25	4.20	3.90	13.40	5.15	6.40	3.70	4.00	.....
21	4.60	4.20	3.90	12.90	4.50	6.30	3.70	4.00	.....
22	4.95	4.20	4.00	11.40	4.65	5.90	3.70	4.00	.....
23	5.80	4.20	4.00	9.65	4.30	6.50	3.70	3.90	.....
24	6.05	4.20	4.00	8.05	4.30	5.70	3.60	3.90	.....
25	5.85	4.20	4.05	7.65	4.35	5.80	3.60	3.90	.....
26	5.80	4.20	4.10	6.65	4.65	5.95	3.50	3.75	.....
27	5.65	4.20	4.20	6.02	4.85	8.40	3.50	3.90	.....
28	5.50	4.20	4.35	6.55	5.00	11.85	3.50	4.20	.....
29	5.35	4.20	.....	5.70	5.65	12.60	3.50	4.00	.....
30	5.20	4.20	.....	6.55	6.80	10.95	3.50	3.80	.....
31	.....	4.10	.....	5.30	.....	9.50	.....	3.75	.....

[1] Observer absent.

A gaging station was established by the United States Geological Survey at Neillsville April 7, 1905, and the following data have been collected:

Discharge measurements of Black River at Neillsville, Wis., in 1905, 1906 and 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1905.		*Feet.*	*Square feet.*	*Feet per second.*	*Feet.*	*Second feet.*
April 7	Hanna and Clapp	192	1,071	3.5	7.7	3,279
May 24	S. K. Clapp	165	471	2.18	4.95	1,024
June 13	M. S. Brennan	192	945	3.15	7.26	2,978
July 11	do	161	392	1.56	4.25	612
August 11	do	151	242	.93	3.3	225
September 25	F. W. Hanna	163	419	1.86	4.35	780
1906.						
January 25	M. S. Brennan	147	198	0.77	4.30	a 152
April 24	do	165	484	1.70	4.75	819
June 3	do	160	436	1.72	4.46	752
1907.						
April 3	A. H. Horton	184	772	3.03	6.52	2,343
June 14	G. A. Gray	147	253	1.31	3.39	334
July 13	do	142	226	1.13	3.52	255
August 15	do	116	108	.61	2.7	66
September 18	do	121	140	.76	3.0	106

NOTE.—*Width* is the actual width of water surface, not including piers. *Area of section* is the total area of the measured section, including both moving and still waters.

a Entirely frozen over; gage height given to water surface; ice 1.3 feet thick. The discharge was 22 per cent of the open-channel rating for gage height 4.30 feet.

Mean daily gage height, in feet, of Black River at Neillsville, Wis., for 1905.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.4	3.7	4.4	2.7	3.3	3.5	3.7	4.0
2	.....	3.4	3.3	4.4	2.6	3.2	3.5	3.5	4.2
3	.....	4.1	3.2	4.9	2.6	3.5	3.4	3.5	3.8
4	.....	5.3	7.7	6.5	2.6	3.4	3.4	3.5	3.7
5	.....	5.2	14.2	8.4	2.9	3.6	3.0	3.5	3.8
6	8.2	4.9	19.8	8.0	2.7	3.3	3.0	3.7	3.5
7	7.7	5.0	16.5	6.8	4.2	3.1	3.1	4.1	3.5
8	6.9	4.6	11.5	5.9	4.0	3.0	2.7	4.1	3.4
9	6.2	4.6	8.8	5.3	4.0	2.9	2.4	3.9	3.3
10	6.0	5.9	7.6	4.7	3.5	2.8	3.1	3.8	3.4
11	5.7	6.6	8.6	4.2	3.3	2.7	3.0	3.7	3.4
12	5.5	6.7	8.0	3.8	3.3	2.8	3.0	3.7	3.5
13	5.1	6.2	7.1	3.9	3.3	2.7	3.0	3.6	3.4
14	4.8	10.7	6.2	4.0	3.3	2.7	3.0	3.5	3.4
15	4.6	10.1	5.5	4.8	3.2	4.3	4.0	3.4	3.5
16	4.3	9.2	5.8	4.5	3.0	6.0	4.9	3.4	3.4
17	3.9	8.7	11.2	4.0	2.9	6.0	5.4	3.4	3.3
18	3.8	8.2	10.7	3.8	3.0	6.1	5.5	3.4	3.0
19	4.2	6.6	8.6	4.2	3.0	8.6	5.6	3.4	3.0
20	3.9	6.0	7.0	4.3	3.0	8.3	6.6	3.3	3.2
21	3.2	5.3	6.0	4.0	3.2	7.5	6.9	3.2	3.1
22	3.1	5.1	5.2	3.8	3.5	6.3	6.5	3.2	3.1
23	3.1	4.9	4.5	3.3	3.4	5.8	5.9	3.2	3.3
24	3.5	4.7	4.1	3.1	3.6	4.7	5.5	3.5	3.5
25	3.4	4.3	3.9	3.1	3.4	4.2	5.0	4.2	3.5
26	3.4	4.2	3.7	3.0	3.3	3.9	4.6	4.6	3.5
27	3.4	4.1	3.5	2.9	3.2	3.8	4.4	4.5	3.4
28	3.4	3.9	3.3	2.9	3.0	3.7	4.1	4.3	3.4
29	3.4	3.9	3.3	2.8	3.4	3.6	3.9	3.9	3.4
30	3.4	3.8	3.5	2.8	3.5	3.8	3.7	3.7	3.5
31	.....	3.8	.....	2.7	3.3	.....	3.6	.....	3.5

Note.—No ice record at this station.

Daily gage height, in feet, of Black River at Neillsville, Wis., for 1906.

Day.	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.5	4.1	5.1	9.4	4.2	5.1	3.7	3.2	3.2	2.7	4.2	5.5
2	3.3	4.1	5.0	11.8	4.6	4.8	3.5	3.0	4.5	2.9	3.9	5.2
3	3.4	4.1	5.2	12.0	5.0	4.3	3.9	2.8	4.5	2.7	3.8	4.9
4	3.5	4.1	5.0	11.6	5.2	4.0	4.2	2.6	4.7	2.7	3.9	4.5
5	3.4	4.0	4.9	11.3	5.1	4.2	4.0	2.8	4.5	2.7	3.8	4.2
6	3.4	4.0	4.9	11.0	4.7	6.3	3.6	3.0	3.0	2.5	3.7	3.8
7	3.5	4.0	4.8	10.6	4.4	6.9	3.3	2.9	3.8	2.5	3.7	4.2
8	3.5	3.9	4.8	11.4	4.2	6.6	3.1	2.8	3.4	2.5	3.7	4.5
9	3.4	3.9	5.3	10.7	4.3	5.9	3.0	2.4	2.9	2.5	3.6	4.7
10	3.5	3.8	5.1	10.0	4.3	5.4	3.1	2.4	3.0	2.5	3.7	4.8
11	3.5	3.8	4.9	8.9	4.1	4.6	3.0	2.4	3.0	2.7	3.6	4.8
12	3.5	3.8	4.9	8.7	3.9	4.1	3.0	2.5	3.0	2.4	3.6	4.8
13	3.5	4.0	4.8	8.5	6.9	3.8	2.8	2.4	3.0	2.4	3.3	4.6
14	3.5	3.9	4.7	8.8	7.3	3.5	2.8	2.4	2.9	2.4	3.2	4.3
15	3.6	3.9	4.6	8.5	6.6	3.3	2.8	2.3	2.9	2.4	3.3	4.3
16	3.6	3.9	4.5	7.6	5.9	3.2	2.7	2.3	3.3	2.5	3.2	4.5
17	3.7	3.8	4.5	6.7	5.4	3.1	2.7	2.4	3.3	2.5	4.1	4.6
18	3.8	3.9	4.4	6.2	4.9	3.0	2.6	2.4	3.4	2.7	5.1	4.6
19	3.8	3.9	4.3	6.0	4.5	2.9	2.7	2.3	3.3	2.7	4.8	4.5
20	3.8	4.1	4.3	6.0	4.1	3.0	2.7	2.3	3.2	3.0	4.6	.....
21	4.0	4.2	4.4	5.8	4.0	3.1	2.6	2.2	3.2	3.5	4.4	.....
22	4.0	4.3	4.3	5.4	4.0	3.6	2.6	2.6	3.1	3.4	3.7	.....
23	4.0	4.4	4.2	4.9	4.1	3.9	2.2	3.0	3.0	3.4	3.8	.....
24	4.0	4.6	4.1	4.8	4.2	4.1	2.1	3.8	3.2	3.7	3.6	.....
25	4.0	4.8	4.2	4.4	6.0	3.9	2.1	4.1	3.2	4.2	3.8	.....
26	4.0	4.9	5.1	4.4	5.9	3.7	2.4	4.4	3.1	5.2	5.5	.....
27	4.1	5.1	6.0	4.3	9.3	3.9	2.4	4.3	3.0	5.2	6.7	.....
28	4.1	5.1	6.6	4.2	8.3	4.1	2.5	4.1	3.0	4.9	6.6	.....
29	4.1	.....	7.2	4.1	7.2	4.2	2.4	3.9	2.9	4.7	6.3	.....
30	4.1	.....	[1]11.5	4.2	6.5	3.9	4.0	3.7	2.8	4.5	6.2	.....
31	4.1	.....	8.5	.....	5.8	.....	3.7	3.4	.....	4.3	.....	.....

[1] Ice jam.
Note.—Ice conditions January 1 to March 30 and December 20 to 21.

Mean daily gage height, in feet of Black River at near Neillsville, Wisconsin, for 1907.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.70	4.60	3.70	3.3	2.5	2.5	3.2	2.6	2.7
2	.....	6.90	4.50	3.40	3.5	2.4	2.4	3.1	2.6	2.8
3	.....	6.60	4.30	3.20	3.4	2.3	2.4	3.1	2.7	2.8
4	.....	6.90	4.10	3.20	3.6	2.3	2.4	3.1	2.7	2.7
5	.....	6.70	4.00	3.10	6.9	2.4	3.2	3.1	3.0	3.0
6	.....	6.40	3.80	3.00	4.6	2.4	2.6	3.2	3.0	2.8
7	.....	6.50	3.80	3.00	4.1	2.4	2.5	3.3	2.9	2.7
8	.....	5.90	3.60	2.90	5.1	2.4	2.5	3.1	2.7	2.8
9	.....	5.70	3.60	2.90	4.5	2.4	2.3	3.1	2.9	2.9
10	.....	5.80	3.50	2.80	4.0	2.4	2.7	3.0	2.9	2.7
11	.....	5.60	3.50	3.00	3.6	2.6	2.3	3.0	2.8	2.8
12	.....	5.60	3.40	3.10	3.3	2.5	2.2	3.1	2.8	2.9
13	.....	5.40	3.40	3.40	3.1	2.4	2.2	3.0	2.6	2.8
14	.....	5.00	3.60	3.50	3.3	2.4	2.4	3.0	2.5	2.7
15	.....	4.80	5.20	3.20	3.2	2.4	2.3	2.9	2.7	2.7
16	.....	4.70	5.90	3.00	3.2	2.5	2.6	3.4	2.6	2.5
17	.....	4.60	5.70	3.00	3.1	2.4	2.5	2.9	2.7	3.0
18	.....	4.40	5.30	3.00	3.0	2.2	2.6	2.8	2.7	2.5
19	.....	4.40	4.70	3.00	3.0	4.3	6.5	2.8	2.6	2.7
20	.....	4.20	4.30	3.10	3.0	3.6	7.0	2.8	2.6	2.7
21	.....	4.10	4.00	4.00	3.0	3.2	6.4	2.7	2.7	2.6
22	.....	4.00	5.60	6.90	3.3	3.2	5.8	2.5	2.8	.. (1) .
23	9.20	3.90	5.20	3.90	3.0	3.3	5.3	2.5	2.7	.....
24	10.10	4.00	4.80	3.90	2.8	2.9	4.8	2.5	2.9	.....
25	11.30	4.10	4.50	3.50	2.7	2.7	4.5	2.5	3.0	.....
26	12.40	4.30	5.00	3.20	2.7	2.7	4.0	2.5	3.0	.....
27	12.40	4.20	4.80	3.00	2.6	2.7	3.8	2.6	2.9	.....
28	11.00	4.20	4.40	2.90	2.5	2.6	3.6	2.6	2.9	.....
29	11.80	4.60	4.20	3.10	2.9	2.5	3.4	2.5	2.9	.....
30	10.70	4.70	3.80	3.00	2.5	2.5	3.3	2.6	2.7	.....
31	9.10	.....	3.60	.....	2.4	2.5	.....	2.6	.....	.....

[1] Frozen.

Estimated monthly discharge of Black River at Neillsville, Wis., for 1905–6.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
April (6-30)	3,900	177	1,036
May	6,910	267	1,768
June	23,000	205	3,840
June	23,060	205	3,840
August	635	60	229
September	4,340	80	918
October	2,570	20	750
November	870	205	392
December	635	150	292
1906.			
April	8,700	635	3,860
May	5,180	473	1,450
June	2,570	126	730
July	635	20	184
August	750	26	188
September	930	105	274
October	1,250	44	298
November	2,400	205	733
December (1–19)	1,460	424	874

Note.—Values for 1906 are good, except July and August, which are fair. During the frozen period the discharge probably seldom exceeded 500 second-feet and attained a minimum of at least 150, and probably much less.

Rating table for Black River at Neillsville, Wis., for 1905 and 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage heighth.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
2.10	20	3.60	338	5.10	1,185	7.20	2,850
2.20	26	3.70	379	5.20	1,250	7.40	3,050
2.30	34	3.80	424	5.30	1.315	7.60	3,250
2.40	44	3.90	473	5.40	1,385	7.80	3,460
2.50	56	4.00	525	5.50	1,455	8.00	3,680
2.60	70	4.10	579	5.60	1,525	8.20	3,900
2.70	86	4.20	635	5.70	1,600	8.40	4,120
2.80	105	4.30	692	5.80	1,675	8.60	4,340
2.90	126	4.40	750	5.90	1,750	8.80	4,580
3.00	150	4.50	810	6.00	1.825	9.00	4,820
3.10	177	4.60	870	6.20	1.985	10.00	6,020
3.20	205	4.70	930	6.40	2,145	11.00	7,300
3.30	235	4.80	990	6.60	2,310	12.00	8,700
3.40	267	4.90	1,055	6.80	2.480		
3.50	301	5.00	1,120	7.00	2,660		

NOTE.—The above table is applicable only for open-channel conditions. It is based upon 8 discharge measurements made during 1905 and 1906. It is well defined between gage heights 3.3 feet and 7.7 feet. Beyond these limits the discharge is only approximate.

WATER POWERS.

It is many years since Black River was used for lumbering, and as the surrounding country is well settled, it seems likely that the near future will see a demand for the available water powers. These powers, while not of the largest, are so situated as to be cheaply developed. The river has no large tributaries, but many of its numerous small feeders are now developed and used to run grist and saw mills. At the present time several projects are being exploited which look to the employment of these powers by interurban electric railroads and other enterprises in near-by cities.

Dam Site in Sections 1 and 2, Township 18 North, Range 8 East.—Chapter 206, Laws of 1903, granted a charter to the La Crosse and Northern Railway Company to build a dam not exceeding 24 feet above low water mark, either on lot 5 of section one or on lot 7 of section 2, both in Township 18 north, Range 8 west. The drainage area above this point is about 2,200 miles, so an ordinary low water flow of at least 500 second feet would be expected equivalent to 1.320 theoretical horsepower.

The construction of this dam has not as yet begun. The utilization of this power would be of special importance to the proposed interurban between La Crosse and Black River Falls.

Black River Falls Dam.—The first dam in the river is at Black River Falls and is of timber construction. The power developed

Fig. 1. DAM AT BLACK RIVER FALLS. PARTLY CARRIED AWAY BY HIGH WATER.

Fig. 2. ROSS EDDY IN HIGH WATER. BLACK RIVER.

is owned by the city of Black River Falls, with turbines working under a head of 13 feet, and by J. J. McGillivray, with turbines under a head of 16 feet. The present tailrace could be lowered 3 or 4 feet, and the crest of the dam could be raised the same amount without flooding. This improvement would give a total head of 20 feet. The turbines now installed develop about 345 horsepower, which is used to run an electric light plant, a sash and door mill, a wagon shop, and a grist mill.

Chapter 491, Laws of 1905, granted to the present owner the right of increasing the head of the dam 4 feet. The drainage area above this point is about 1,570 square miles. A view of this dam, at time of high water is shown in Plate XXXII.

Black River Falls to Neillsville.—Because of the high, rocky banks and high gradient of this river, dams of 15 to 20 feet head could be installed nearly every 2 or 3 miles between Black River Falls and Neillsville, but only a few of the largest undeveloped powers will be described.

The first dam site above Black River Falls is located near the south line of Section 1, Township 21 north, Range 4 west, just below the Chicago, St. Paul, Minneapolis and Omaha Railway bridge. At this point the rocky banks form a narrow gorge and are high enough to furnish a head of 30 feet or more. This site belongs to the Black River Improvement Company, of La Crosse, Wisconsin. Twenty feet would develop all the fall to center of section 17, township 22, range 3 west.

Northeast Quarter Section 17, Township 22 North, Range 3 West, Dam Site.—At this point the banks of the river are high and steep. Between this point and the railroad crossing at Hatfield the river has a total fall of nearly 50 feet, all of which could be developed at this point by a dam not to exceed 500 feet in length. This dam site is less than three miles from the main line of the Chicago, St. Paul, Minneapolis and Omaha Railway.

Hatfield Dam Site.—The legislature of 1903 granted a charter to build a dam at Hatfield, in section 3, township 22 north, range 3 west, to E. G. Boyton and Orlando Holway, but said charter was to be void unless the dam were constructed before the end of 6 years. This charter provided for a head of 35 feet. It is reported on good authority that active steps are now being taken to improve this power.

Surveys have been made and preliminary plans drawn for a dam at Hatfield with a head of 50 feet and this includes a canal from the head of this proposed dam extending downstream about 2 miles. Such a canal would develop a total head of 86 feet by one power plant. But the 50 foot dam would cover up the next important dam site above, viz.:

The "Dells" Dam.—This old logging dam is located in Section 18, Township 23 north, Range 2 west, at the head of a rapids which comprise a fall of 25 feet in a distance of less than a mile. A 30-foot dam in the site of the present "Dells" dam would back the water to the foot of Ross Eddy and this head, in connection with a short canal below the present dam, would develop a total head of 40 feet.

Ross Eddy Rapids.—Ross Eddy, a view of which is shown in Plate XXXIII comprises a fall of 26 feet in a distance of a mile. The total fall in the river between the mouth of O'Niell Creek and Cunningham Creek, a distance of 3½ miles, is 45 feet. Mr. L. B. Ring of Neillsville has a charter for a 20-foot dam in either Section 22 or 26, Township 24 north, Range 2 west, granted in 1901. Near the southeast corner of Section 22, Township 24 north, Range 2 west, the river is flowing due east but in the next 2,000 feet it turns abruptly and flows south for a distance of 2,000 feet when it turns abruptly again to the west. Mr. Ring has proposed to build a 20-foot dam in the S. E. ¼ of section 22 and then by a short canal 95 rods long (in earth) cut off this long bend and deliver the water to the turbines below the bend under a head of 42 feet. The outlet of such a canal would be in a favorable place for the power house because of its protection from ice and floods.

Weston Rapids.—These rapids, including a fall of 20 feet are located in Section 2, Township 24 north, Range 2 west, about 2 miles from Neillsville, a city of 2,200 inhabitants. Nineteen feet of fall are concentrated in a distance of 4,000 feet. Both banks are high enough at the head of the rapids to enable a dam to be built with a head of about 18 feet. This would back the water up to a point 4½ miles above.

The right or west bank is high enough to allow of a canal at this level to a point nearly opposite the foot of Weston Rapids. While expensive, this canal would develop a head of about 35 feet. Even with a head of 25 feet the pondage is estimated at 225 acres.

At the present time the owners, the Neillsville Light and Power Company, are trying to sell their rights to the city. The occasionally remarkably low water flow of this river makes necessary the installation of an auxiliary steam plant which greatly reduces the value of the stream as a power producer. This extreme low flow may be due to the regulation of the flow by the dams at Greenwood and Hemlock.

Rapids in Section 16, Township 25 North, Range 2 West.—These rapids nclude a fall of 14 feet in a distance of about 3,000 feet and all in the N. E. ¼ of above section 16. The banks would here allow a dam with a head of approximately 20 feet.

Rapids in Section 4, Township 25 North, Range 2 West.—About 1,000 feet north of the south line of section 4 a 15-foot dam could be secured at reasonable cost.

Rapids in Section 21, Township 26 North, Range 2 West.—About a quarter of a mile from the south line of section 21 the banks are suitable for a dam with a head of 20 feet. This would develop all the fall up to Greenwood.

Greenwood Dam.—Under a charter granted by Chapter 470, Laws of 1895, the city of Greenwood has constructed a concrete dam near the north line of Section 34, Township 27 North, Range 2 West. This dam develops a head of 12 feet and the power is used to light the city. Between the back water of this dam and the foot of the next dam above is a fall of about 10 feet.

Hemlock Dam.—This dam is located in Section 16, Township 27 North, Range 2 West. It was originally built for logging purposes and has been repaired and modified several times. At the present time the dam develops a head of 18.5 feet. Four turbines rated at 175 h. p. are installed and used to run a grist and saw mill. The power is owned by Theodore Withee. This dam backs the water for a distance of 2¼ miles and is the last dam on the river, used for power.

In the 10 miles between the back water of Hemlock dam and the Wisconsin Central bridge near Withee the river has a total fall of only 38 feet. The banks for the greater part are low and in many places swampy, giving no opportunities for the development of power.

Because of the unusually steep gradient in the branches of Black River, a water power of from 10 to 20 feet can be located at frequent

intervals on these streams. Several of the many mills in such locations report an available head of from 35 to 40 feet. In nearly every case timber and rock are found at or near the dam sites.

Railroads.—That portion of Black River containing the important powers is fairly well served by railroads. The river is crossed by the Chicago, St. Paul, Minneapolis, and Omaha Railway four times, and once each by the Wisconsin Central Railway and the Green Bay and Western Railroad.

Dams on Tributaries of Black River.

River.	Location.	Owner.	Head	Turbine. H. P.	Use of power.
Robinson's Creek.	Sec. 25, T. 20 N., R. 4 E.	G. W. Brenner.....	16	50	Flour and feed.
..... do	Sec. 19, T. 20 N., R. 5 E.	.....	20	.....	Undeveloped.
..... do	Sec. 20, T. 20 N., R. 2 E.	H. B. Mills Est	12	40	Saw and planing.
Beaver Creek.....	Sec. 30, T. 20 N., R. 7 E	Ettrick oo'len Mills	10	20	Manufacture of woolens.
..... do	Galesville	Galesville Mill'g Co.	14	150	Flour and electric light.
..... do	Sec. 30, T. 20 N .R 7 E.	Beaver Valley Roller Co.	10	55	Flour and feed.
Mill Creek	Sec. 29, T. 19 N., R. 6 E.	N. Bend Milling Co..	37	100	Flour and feed.
Douglas Creek....	Melrose.....	Melrose Mill.....	34	90	Flour and feed.
Hall Creek...	Merrillan.....	Andrews and Co	12	25	Flour and feed.
Squaw Creek	Sec. 21, T. 21 N., R. 4 E.	Squaw Creek Woolen Mills...	13	33	Manufacture of woolens.
..... do	... do .... do ...	.....	10	.....	Undeveloped.
Robinson's Creek.	Sec. 22, T. 20 N., R. 4 E	.....	10	.....	Undeveloped.
Sailor Creek	Perkinstown	F. L. Diederich	12	25	Saw mill.

MISSISSIPPI RIVER

CHIPPEWA RIVER SYSTEM.

Topography and Drainage.—The Chippewa drainage system has its source in over a hundred lakes, large and small, with many connecting swamps, near the Michigan boundary and only 20 miles from Lake Superior. The drainage area has a length of 180 miles, a maximum width of 90 miles, and an average width of nearly 60 miles. The general direction of the drainage, except in the extreme Western part, is toward the southwest. Chippewa River unites with the Mississippi at the foot of Lake Pepin, after a course of 267 miles. The total area drained by the river is 9,573 square miles, of which about 6,000 include the most unsettled region of northern Wisconsin. This area includes the richest forests of the State, of both soft and hard timber. Although lumbering operations have been very active here for many years, considerable pine timber still remains, chiefly at the upper headwaters, but it is fast disappearing. Most of the large tracts of pine lands are owned by large corporations, and many of them are reached by long lines of logging railroads, which in many cases have been purchased by the trunk-line railroads and made a part of their systems. The extensive use of such railroads has greatly relieved the rivers of the burden of transporting logs, and correspondingly added to the value of the rivers for water-power purposes.

The main line of drainage runs very nearly along the central line of the basin, but the name of Chippewa River is not given to this continuation of the principal stream. The river divides 112 miles from the mouth; one branch, the prolongation of the line of drainage, called the Flambeau, rises in the lakes near the Michigan line, at an elevation of a little over 1,600 feet above the sea; the other branch, rising farther west and flowing more directly south, receives the name Chippewa. The Flambeau drains 1,983 square miles, while Chippewa River, above their junction, drains only 1,777 square miles. About

56 miles above this junction the Chippewa again divides into East and West branches, the one flowing from the northeast, the other from the north, draining, respectively, 278 and 480 square miles.

The lakes of this region are situated in two widely separated groups, one in the extreme northeastern part, at the headwaters of Flambeau River, and the other in the northwestern part, at the headwaters of what is known as the main stream and of Red Cedar River. The remainder of the area is almost devoid of lakes. The wooded regions, however, include very large areas of cedar and tamarack swamps.

Geology.

The pre-Cambrian crystalline rocks form the underlying strata in the area above Chippewa Falls, while below that point they are replaced by the Cambrian sandstone. The entire area above Chippewa Falls is covered with glacial drift, so that the rock appears only in the river bed. The country is level or rolling. In the southern part of the area the rivers have eroded deeply into the drift and rock, but in the northern portion they have not cut much below the surface.

With only a few exceptions (the most notable one at Eau Claire) all the many and important water powers on Chippewa River are found in the region of the pre-Cambrian crystalline rocks, but because of the deep drift the powers on the upper streams occur as bowlder rapids.

PROPOSED RESERVOIR SITES.

According to detailed surveys made by United States engineers, this drainage area is favored with an unusual number of excellent sites for reservoirs. A list of these sites, with valuable data concerning them, is given in the following table:

Proposed United States Government dams on Chippewa River.[1]

Location and name.	Length.		Maximum height.		Drainage area above reservoir.
	Dam.	Dike.	Dam above low water.	Dike.	
East Branch Chippewa River:	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. miles.*
Bear Lake	1,015	200	19.5	8.5	244.5
Little Chief Lake	710	.....	24.0	.....	57.5
West Branch Chippewa River:					
Moose Lake	1,235	160	25.7	1.5	214.8
Pakwawang Lake	900	.....	25.5	.....	257.2
Court Oreilles	260	100	3.5	5.0	114.0
Chippewa River, Paint Creek	320	.....	23.0	.....	3,943.1
Total	4,740	460	.....	.....	4,830.7
Butternut Creek, Butternut Lake	336	.....	10.0	.....	40.0
Manitonish River, Rest Lake	250	75	15.0	2.5	211.6
North Fork Flambeau, Bear Creek	2,500	2,000	15.0	10.5	154.5
Dore Flambeau:					
Round Lake	170	250	10.0	10.0	63.0
Squaw Lake	250	.....	9.0	.....	49.0
Turtle River, Park Lake	297	.....	15.0	.....	174.0
Grand total	8,543	2,785	.....	.....	5,512.8

[1] Rept. Chief Eng. U. S. Army, 1880, p. 1648.

Proposed United States Government dams on Chippewa River—Continued.

Location and name.	Supply (one-third of 30 inches rainfall).	Capacity of reservoir.	Surplus over reservoir capacity.	Supply from reservoir for 90 days.	Cost of dam and dike.
East Branch Chippewa River:	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Sec.-feet*	
Bear Lake	5,677,951,910	1,119,148,856	4,564,803,054	143.1	$25,925
Little Chief Lake	1,337,627,935	771,332,009	566,295,926	99.2	40,702
West Branch Chippewa River:					
Moose Lake	4,976,626,153	2,-01,783,402	1,234,725.814	260.0	45,090
Pakwawang Lake	5,972,880,292	7,692,997,229		989.3	36,449
Court Oreilles	2,647,388,621	2,647,388,621	.....	340.4	2,492
Chippewa River, Paint Creek	91,569,456,760	505,336,720	91,064,120,040	65.0	60,000
Total	112,181,931,671	14,751,986,837	97,429,944,834	1,897.0	240,658
Butternut Creek, Butternut Lake	928,908,288	585,446,400	343,461,888	75.8	5,216
Manitonish River, Rest Lake	4,897,100,264	1,840,000,000	757,813,112	236.6	7,665
North Fork Flambeau, Bear Creek	3,107,280,000	5,406,567,152		695.3	47,500
Dore Flambeau:					
Round Lake	1,382,304,000	1,303,0 6,416	79,267,584	167.6	11,550
Squaw Lake	864,240,400	731,808,000	132,422,400	94.1	4,000
Turtle River Park Lake	4,026,198.428	620,782,720	3 405,415,708	79.8	9,941
Grand total	127,387,953,051	25,239,627,525	102,148,325,526	3,245.7	325,530

It will be seen from the above table that the systematic operation of these proposed reservoirs for this purpose would increase the ordinary low-water flow of the river by 3,245 second-feet for ninety days a year, thus about doubling the present available water power of the river. Estimated upon a run-off of one-fourth of the annual rain-fall, assumed at 30 inches, this increase would be 2,800 second-feet for ninety days.

Experiments now being carried on by the Government in Minnesota on five similarly constructed dams will doubtless determine whether the reservoir system at the headwaters of the Mississippi will be extended to include any of the above proposed dams. Probably the main obstacle to building such reservoirs at the present time by the Government is the fact that, owing to the settling up of this region, the land has now become very valuable. The total cost would seem to be prohibitive. That the owners of water powers are in favor of such Governmental control is certain. Besides adding to the amount of power, such a system would prevent, in large measure, the danger to dams by floods. The building of even a part of these dams would have marked economic value. Already private enterprise has developed some of the smaller of these reservoirs.

RAILROADS.

The logging interests of the river are controlled by the Chippewa Falls Lumber and Boom Company, with headquarters at Chippewa Falls, a thriving city of about 10,000 population. The largest city of this region is Eau Claire, population 17,517, situated at the junction of Eau Claire and Chippewa rivers. This city has numerous manufactories and sawmills, and is quite a railroad center. From its mouth to Chippewa Falls, Chippewa River is paralleled by the Chicago, Milwaukee and St. Paul Railway, and between Eau Claire and Chippewa Falls by the Chicago, St. Paul, Minneapolis and Omaha and the Wisconsin Central railways, besides an electric line. Chippewa River, above Chippewa Falls, is reached by the Chicago, St. Paul, Minneapolis and Omaha Railway for a distance of about 25 miles. In addition, the drainage area is crossed east and west by the Minneapolis, St. Paul and Sault Ste. Marie Railway and north and south by the Wisconsin Central Railway.

Several railroad lines are projected or being built in this section, and the agricultural and manufacturing interests are fast supplanting that of lumber. Where the timber has been cut the land is being taken up by settlers, so that there is but little second-growth timber. The people seem prosperous, and numerous companies are on the point of investing large sums in the manufacturing interests of the neighborhood, thereby utilizing the undeveloped water powers.

RAINFALL AND RUN-OFF.

The extensive forests of this area combine with the numerous lakes and swamps to give a naturally uniform flow by preventing the rapid escape of the rainfall into the streams. Since 1903 the United States Geological Survey has maintained gaging stations near Eau Claire, on Chippewa River, and at Ladysmith, on the Flambeau. As a result of the operation of logging dams, the minimum discharge is found to be only 1.6 per cent of its maximum discharge for the year. The following tables give discharge data of Chippewa River at Eau Claire, covering the period from November 14, 1902, to December, 1907, and also a monthly summary of the same.

Discharge measurements of Chippewa River at highway bridge, Shawtown near Eau Claire, Wis., 1902 to 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge
		Feet.	*Square feet.*	*Feet per second.*	*Feet.*	*Second-feet.*
1902.						
November 13	L. R. Stockman		3,666	3.88	8.70	11,134
December 6	do		2,809	1.03	4.45	2,871
December 28	do		2,798	1.09	4.60	3,063
1903.						
January 17	L. R. Stockman		2,509	.79	4.15	[1]1,979
February 17	do		2,315	.77	3.80	[1]1,779
March 9	do		2,877	1.32	4.85	[2]3,818
April 6	do				7.40	10,688
May 5	do		5,726	4.62	11.85	26,458
June 15	do		3,105	1.64	4.70	4,107
July 10	do		4,761	3.61	9.25	17,167
August 20	do		2,372	1.83	5.13	4,336
September 5	do		3,626	2.21	6.20	8,063
October 13	do		4,637	3.25	8.77	15,087
November 24	do		2,281	1.54	4.90	3,511
1904.						
January 11[1]	E. Johnson, Jr.	310	2,429	.99	3.80	2,454
May 14	do	385	4,272	3.42	8.40	14,610
May 24	Johnson and Hanna	370	4,074	3.10	7.60	12,630
June 7	E. Johnson, Jr.	426	5,815	4.52	11.25	26,270
July 13	do	354	3,770	2.10	6.55	7,918
August 28	do	322	2,766	.82	4.20	2,274
September 19	do	329	3,122	1.47	5.25	4,581
October 12	F. W. Hanna	495	7,118	5.43	14.80	38,680
October 13	do	457	6,137	4.76	13.10	29,200
November 29	E. Johnson, Jr.	324	2,847	.80	4.44	2,281
1905.						
May 22	S. K. Clapp	200	4,004	3.66	8.80	16,110
June 14	M. S. Brennan	427	5,131	3.83	10.72	19,665
July 12	do	355	3,585	2.09	6.55	7,489
August 12		335	3,062	1.29	5.00	3,948
1906.						
January 21	M. S. Brennan	332	2,772	1.00	4.82	[3]2,761
April 25	do	425	4,808	3.51	9.45	17,071
June 2	do	355	3,646	2.19	6.52	7,985

[1] Frozen.
[2] Partly frozen.
[3] Ice measurement; river partly open. Gage height to bottom of ice, 3.92 feet; ice 1 to 1.2 feet thick. Discharge was about 75 per cent of the open-channel rating for gage height, 4.82 feet.

Note.—Width is the actual width of water surface, not including piers. Area of section is the total area of the measured section, including both moving and still water.

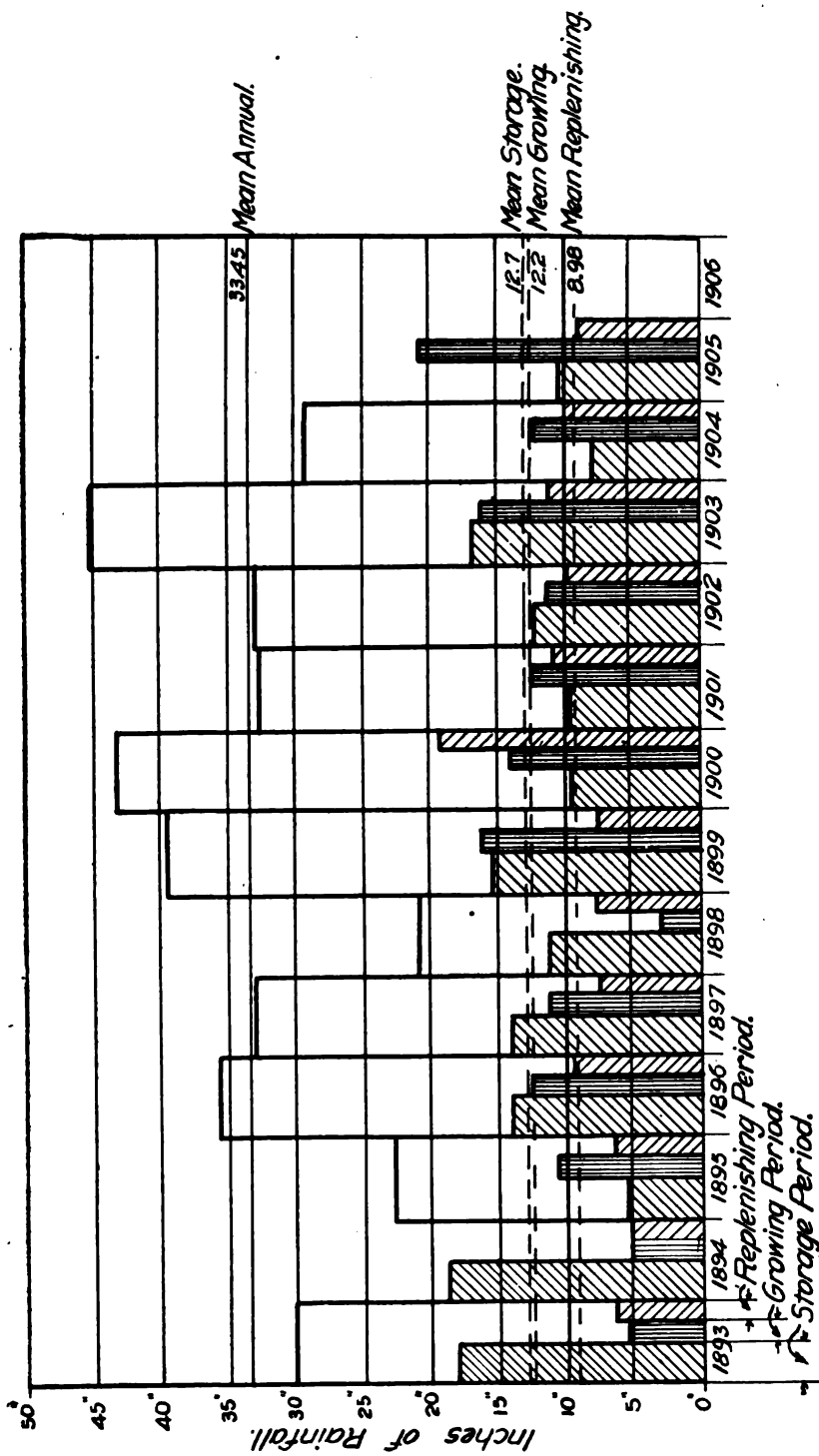


Fig. 10.—Rainfall on the watershed of Chippewa River above Eau Claire, Wis. water shed=9,740 square miles.

Discharge measurements of Chippewa River near Eau Claire, Wis., in 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1907.		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 2	A. H. Horton	450	5,666	4.72	11.78	26,722
June 15	G. A. Gray	351	3,427	2.02	6.06	6,910
July 15	" "	334	2,974	1.56	5.37	4,637
August 16	" "	167	1,900	1.27	4.21	2,417
September 22	" "	466	6,374	4.53	12.92	28,846
September 19	" "	375	4,051	2.98	8.00	12,110
September 27	" "	371	4,208	2.77	7.95	11,657
October 21	" "	197	2,291	1.54	4.87	3,520
November 16	" "	222	2,231	1.50	4.60	3,343
December 19	" "	207	2,179	1.13	3.9	2,469

On December 19 the river was half frozen over.
Ice unsafe. Velocity under ice estimated by velocity at the edge of ice.

Discharge measurements under ice of Chippewa River near Eau Claire, Wis., in 1908.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height Water sur.	Discharge	Av. th. of ice.	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.		
1908. February 15	G. A. Gray	330	2,665	1.04	4.7	2,786	.8	No.

Record ice thickness, winter, 1907–8.

Date.		Feet.
Jan. 14	River closed.	
Jan. 15	Thickness of ice	0.5
Jan. 21	" "	0.5
Jan. 25	" "	0.6
Feb. 2	" "	0.8
Feb. 6	" "	0.9
Feb. 14	" "	0.8
Feb. 25	River opened up.	

Mean daily gage height in feet, of Chippewa River near Eau Claire, Wis., November 14, 1902, to December 31, 1907.

Day.	1902.		1903.											
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	4.30	3.70	3.20	6.85	12.80	(1)	7.05	5.05	5.90	6.90	5.53	(1)
2	.....	.....	4.35	4.25	3.75	7.15	13.10	(1)	8.05	5.20	6.45	7.00	5.53	(1)
3	.....	.....	4.15	4.10	3.85	7.45	12.15	(1)	10.60	5.85	5.65	7.35	5.45	(1)
4	.....	.....	4.20	4.05	3.90	7.95	11.85	(1)	13.50	6.85	5.85	9.90	5.50	(1)
5	.....	4.50	4.40	4.10	3.75	7.85	11.55	(1)	15.30	7.50	5.75	11.25	5.25	(1)
6	.....	4.45	3.90	4.05	3.75	7.40	10.90	(1)	15.20	9.10	6.45	11.65	5.20	4.30
7	.....	4.00	4.15	4.15	3.85	7.50	10.30	6.85	13.75	9.00	5.85	11.60	5.15	4.65
8	.....	4.05	4.40	4.15	4.10	7.90	9.20	5.45	11.30	11.05	6.30	11.15	5.10	4.50
9	.....	4.05	4.20	4.00	4.60	8.55	9.15	6.45	10.30	6.70	8.00	11.35	5.05	4.60
10	.....	4.10	4.40	3.85	5.05	8.00	7.65	5.95	9.40	7.55	8.05	10.95	5.00	4.70
11	.....	4.35	4.80	3.80	5.80	7.60	8.95	6.50	10.10	7.25	9.15	9.95	5.00	4.55
12	.....	4.20	4.65	3.85	6.00	8.15	12.00	5.90	9.95	6.75	12.85	9.45	5.00	4.50
13	.....	4.45	4.75	3.90	7.05	7.70	13.25	9.25	8.90	6.85	14.00	9.00	5.05	4.70
14	13.70	4.25	4.60	3.90	8.20	7.65	13.40	3.75	8.10	6.90	16.75	8.80	5.30	4.85
15	10.20	4.55	4.85	3.90	8.05	7.80	13.25	4.65	7.80	9.65	17.85	8.45	5.40	4.75
16	12.40	4.25	4.30	4.50	7.00	7.80	11.85	4.95	7.20	5.10	18.50	7.75	4.95	4.70
17	13.05	4.30	4.20	4.10	7.00	7.50	10.45	4.95	6.50	6.80	17.45	7.70	4.95	4.60
18	12.60	4.10	4.30	4.15	7.55	6.75	9.90	4.90	8.80	6.65	15.50	7.40	4.25	4.65
19	11.35	4.30	4.65	4.30	11.80	6.65	9.15	4.30	5.95	6.00	13.45	7.55	4.40	4.65
20	9.60	4.25	4.40	4.25	13.95	6.85	9.15	5.15	6.70	5.10	11.80	7.05	4.15	4.60
21	8.50	4.30	4.50	4.20	13.65	6.80	9.30	4.70	6.15	5.15	10.50	7.05	4.20	4.60
22	7.55	4.25	4.35	3.35	12.65	6.65	9.50	4.20	5.70	7.50	9.95	6.75	4.35	4.80
23	7.40	4.50	4.35	3.80	11.70	6.40	9.05	4.20	5.60	5.60	9.15	6.70	4.85	4.70
24	7.15	4.70	4.45	4.15	10.45	6.40	9.10	4.15	6.00	5.10	7.80	6.55	4.95	4.80
25	7.00	4.30	3.50	4.05	9.40	8.60	9.85	4.25	9.20	5.15	7.60	6.30	4.95	4.00
26	6.45	4.20	4.20	3.90	8.75	6.55	10.20	4.15	5.25	5.25	7.00	6.15	4.90	4.40
27	6.20	5.10	4.10	3.95	8.40	7.15	12.50	6.75	5.05	4.70	7.60	5.95	4.85	3.40
28	6.00	4.60	4.10	3.85	7.75	7.00	15.15	4.20	5.20	5.45	7.05	6.10	4.60	3.70
29	5.75	4.50	3.85	.....	7.60	7.30	16.70	4.60	5.15	5.60	7.05	6.10	.....	3.60
30	5.55	4.95	4.15	.....	7.15	11.70	16.10	4.95	5.15	5.20	7.05	6.10	.....	3.60
31	.....	4.50	4.25	.....	6.80	.....	.....	.....	5.10	5.60	.....	5.90	.....	3.40

[1] Observer absent.

Day.	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.[1]												
1	[2]4.90	.....	.....	6.25	9.00	8.45	8.10	4.42	4.58	6.31	6.79	3.93
2	[2]5.15	.....	.....	6.72	8.65	7.65	8.52	4.80	5.05	5.24	6.84	3.93
3	.....	.....	.....	6.50	8.63	7.65	8.28	4.38	8.18	8.27	6.80	3.93
4	[2]5.00	.....	.....	6.52	8.28	8.85	8.02	4.78	7.52	5.65	6.61	3.45
5	.....	.....	[2]4.80	6.60	8.10	9.00	10.32	4.32	8.30	5.30	5.91	4.42
6	.....	[4]4.80	.....	7.17	8.03	10.95	10.12	4.12	7.30	5.27	6.41	4.28
7	.....	.....	.....	7.60	10.13	11.30	9.63	3.45	7.52	4.82	6.08	4.26
8	.....	.....	.....	9.10	8.50	10.85	8.93	4.62	7.12	9.12	5.35	4.28
9	[2]4.80	.....	.....	9.67	8.83	9.85	7.22	5.10	6.72	7.86	5.35	4.37
10	.....	.....	.....	9.72	9.35	8.92	7.10	5.42	7.95	13.35	5.60	4.36
11	.....	.....	.....	9.70	9.25	7.95	7.20	5.35	5.03	15.07	5.38	4.20
12	.....	.....	[4]4.95	9.32	8.85	7.80	6.72	4.38	5.28	14.93	5.02	4.34
13	.....	[3]5.00	.....	9.05	8.78	7.80	6.60	4.12	5.42	13.15	6.27	4.39
14	.....	.....	.....	8.32	10.20	7.45	5.88	3.50	5.35	11.38	4.82	4.20
15	.....	.....	.....	8.50	8.00	7.80	5.07	3.80	5.38	10.30	6.26	4.34
16	[5]5.00	.....	.....	7.55	8.20	8.35	5.55	4.55	5.42	9.17	5.42	4.32
17	.....	.....	.....	7.25	7.55	6.25	5.35	4.82	7.10	8.10	5.30	4.15
18	.....	.....	.....	7.50	7.22	5.50	5.60	4.65	4.80	8.00	5.47	4.19
19	.....	[6]5.10	4.45	8.38	7.55	5.10	5.50	4.78	4.89	7.08	5.20	4.53
20	.....	.....	4.07	8.20	6.93	6.20	5.10	7.20	4.27	6.85	4.98	4.29
21	.....	.....	4.45	8.13	10.30	6.50	5.47	5.25	4.30	8.35	5.28	4.34
22	.....	.....	4.37	7.45	6.30	5.90	5.05	4.75	4.35	9.25	5.23	4.37
23	[5]5.00	.....	4.32	8.05	6.83	5.80	4.75	4.68	5.10	9.42	5.74	4.55
24	.....	.....	5.62	8.50	7.33	5.50	3.93	4.60	4.24	9.00	4.77	4.38
25	.....	.....	5.95	9.05	9.20	8.95	4.07	5.00	5.76	8.78	4.94	3.31
26	.....	.....	6.45	10.63	12.00	5.55	4.90	5.40	8.18	7.81	5.10	4.19
27	.....	[6]5.30	6.10	10.45	13.48	7.75	4.80	8.15	7.61	8.02	4.85	4.55
28	.....	.....	5.72	9.18	13.63	7.60	5.00	3.58	6.93	7.22	4.55	[7]
29	[6]4.70	.....	5.05	9.55	12.02	7.75	4.88	5.55	9.81	7.55	4.54	.....
30	.....	.....	5.10	9.03	10.67	7.60	6.45	4.92	6.65	7.30	4.46	.....
31	.....	.....	5.32	.....	9.20	.....	5.00	4.52	.....	6.85	.....	.....

[1] River frozen over January 1 to March 18, 1904, but open about 200 to 300 feet above and one-fourth mile below bridge.
[2] Ice 2.0 feet thick at gage; 1.0 foot in middle of channel.
[3] Ice 2.5 feet thick at gage; 2.5 feet in middle of channel.
[4] Ice 2.0 feet thick at gage; 2.0 feet in middle of channel.
[5] Ice 2.0 feet thicker at gage; 1.0 foot in middle of channel.
[6] Ice 2.5 feet thick at gage; 2.5 feet in middle of channel.
[7] River frove December 28 to 31.
[8] Ice 2.0 feet thick at gage; 2.0 feet in middle of channel.

Mean daily gage height, in feet, of Chippewa River near Eau Claire, Wis., November 14, 1902, to December 31, 1905—Continued.

Day	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	(1)	.....	.....	12.00	6.80	6.30	6.80	6.80	6.50	5.15	5.70	4.75
2	4.36	.....	.....	10.20	5.80	6.80	7.40	5.75	6.20	5.55	6.15	5.15
3	.....	.....	.....	11.20	5.90	6.50	6.30	4.35	5.30	7.80	5.45	4.85
4	.....	.....	.....	10.50	6.50	8.20	6.20	4.35	6.10	5.55	5.75	5.65
5	.....	4.80	4.20	10.40	7.50	12.10	6.90	4.75	6.80	4.90	5.65	4.40
6	.....	.....	.....	10.80	6.60	19.20	10.40	5.10	6.50	4.90	5.75	5.40
7	.....	.....	.....	10.20	7.30	.....	10.60	5.25	6.10	7.50	6.10	5.40
8	.....	.....	.....	9.80	7.60	19.60	11.30	5.05	5.65	6.00	6.30	5.90
9	4.40	.....	4.50	9.20	7.30	17.30	10.10	5.30	5.75	4.85	6.05	5.85
10	.....	.....	.....	8.90	8.80	14.50	7.00	5.90	5.10	4.80	6.10	5.35
11	.....	.....	.....	8.70	7.80	13.00	8.10	4.20	4.90	5.50	6.50	5.30
12	.....	.....	4.30	7.40	7.90	12.60	6.90	5.45	5.35	7.90	5.50	5.30
13	.....	5.30	4.30	5.75	7.50	11.50	6.90	5.10	6.90	6.20	5.70	5.30
14	.....	.....	4.25	5.65	9.50	10.00	7.20	5.35	5.85	5.90	5.80	5.25
15	4.80	.....	4.10	6.10	10.70	9.40	7.10	5.70	5.40	5.25	5.20	5.00
16	.....	.....	4.50	5.75	12.20	8.80	7.60	4.45	5.55	6.40	6.20	4.60
17	.....	.....	4.50	6.20	12.90	8.70	6.80	4.45	7.70	7.35	5.50	4.70
18	.....	5.36	4.65	7.00	12.00	10.20	6.50	5.60	10.70	7.80	6.00	4.80
19	.....	.....	4.40	5.60	10.60	12.20	6.60	5.25	7.00	7.90	5.50	4.70
20	.....	.....	4.45	5.45	10.20	11.30	6.70	7.40	10.10	8.95	5.45	4.70
21	.....	.....	4.55	5.40	9.20	10.50	6.00	7.30	10.80	8.50	5.40	4.65
22	4.67	.....	5.50	5.40	8.60	9.10	6.40	8.90	10.30	8.65	4.60	4.85
23	.....	.....	6.20	5.05	8.60	9.00	5.70	5.85	9.20	8.35	5.20	4.55
24	.....	.....	7.10	5.30	8.00	8.80	6.10	6.20	8.40	7.90	5.00	4.60
25	.....	4.95	7.80	5.30	8.10	8.20	5.75	6.40	6.50	7.55	5.20	4.10
26	.....	.....	8.90	6.30	7.50	7.30	5.55	8.30	8.50	7.20	5.70	4.80
27	.....	.....	10.40	5.50	7.70	7.50	4.90	5.30	6.00	7.10	6.05	4.60
28	.....	.....	11.80	4.80	7.00	8.70	4.45	5.00	6.00	7.00	5.70	4.65
29	5.17	.....	13.20	5.05	7.10	7.80	5.30	7.80	7.90	6.60	5.70	4.55
30	.....	.....	13.60	4.85	7.20	5.75	4.45	6.20	6.20	6.50	5.00	4.70
31	.....	.....	12.90	.....	6.90	.....	4.35	6.20	.....	6.40	.....	4.70

Daily gage height, in feet of Chippewa River near Eau Claire, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.62	4.91	5.73	8.38	7.66	10.30	5.88	5.72	8.95	5.32	7.29	6.91
2	.....	.....	.....	9.57	7.58	6.22	8.44	5.06	4.76	5.28	7.04	6.36
3	.....	.....	.....	10.90	7.79	9.00	6.64	4.30	5.28	6.60	7.19	5.81
4	.....	.....	.....	12.27	8.30	7.13	6.12	4.34	9.55	5.40	6.99	6.02
5	.....	4.95	5.45	13.48	8.76	6.20	5.42	3.52	5.82	5.18	6.74	6.04
6	.....	.....	.....	12.46	8.52	7.18	5.76	4.29	4.83	4.85	6.57	5.56
7	.....	.....	.....	12.25	9.00	6.80	7.52	7.92	5.36	4.26	6.55	5.25
8	.....	.....	5.15	12.35	9.00	9.65	4.35	5.51	4.98	4.24	6.76	5.08
9	.....	5.05	.....	12.90	6.78	9.82	5.20	5.27	4.48	4.52	6.78	5.07
10	.....	.....	.....	13.55	7.16	9.24	5.22	7.87	6.25	4.36	7.20	4.86
11	.....	.....	.....	13.50	7.44	8.00	6.18	5.52	5.35	6.40	6.80	5.28
12	.....	5.19	5.21	12.99	6.86	8.92	5.32	3.68	4.79	5.34	6.92	5.34
13	.....	.....	.....	12.95	6.68	7.56	4.98	6.62	4.82	5.04	6.65	5.56
14	4.25	.....	.....	13.73	10.06	7.50	5.13	5.05	5.04	3.55	6.54	5.46
15	.....	5.00	4.96	14.56	10.26	5.84	5.25	4.62	6.12	4.82	5.95	5.75
16	.....	.....	.....	14.71	8.77	6.74	5.58	4.51	6.50	4.90	6.55	5.12
17	.....	.....	.....	13.55	7.39	6.42	6.29	4.52	7.78	4.64	6.20	5.65
18	.....	.....	.....	12.62	7.95	7.30	5.28	6.81	6.84	5.12	6.40	5.42
19	.....	5.24	4.95	12.08	8.26	5.22	5.60	5.08	6.59	4.45	6.76	5.48
20	4.21	.....	.....	11.60	6.60	4.90	5.72	4.03	6.33	5.39	6.54	5.06
21	.....	.....	.....	11.36	7.66	5.02	5.78	4.56	5.66	4.84	6.68	5.04
22	.....	5.09	.....	11.20	6.08	5.60	4.30	4.77	6.25	5.59	5.76	5.14
23	.....	.....	.....	10.41	6.82	8.51	4.32	8.73	6.45	5.88	6.10	4.76
24	5.13	.....	.....	10.02	10.06	5.26	5.04	5.28	7.68	7.02	5.98	5.41
25	.....	.....	5.42	9.62	6.75	5.04	6.69	10.20	6.70	6.28	5.22	4.56
26	.....	5.23	4.88	9.28	8.16	6.11	5.32	5.32	6.34	8.51	6.15	4.58
27	.....	.....	5.32	8.76	9.82	6.41	4.77	8.33	5.95	9.10	6.57	4.89
28	.....	.....	5.42	8.45	10.94	6.86	4.88	5.54	5.62	8.54	7.18	4.81
29	4.65	.....	5.28	8.07	11.05	8.87	3.56	9.33	6.22	8.32	7.43	4.82
30	.....	.....	5.50	7.36	9.82	5.54	4.72	5.59	5.38	7.84	7.34	4.38
31	.....	.....	7.47	.....	9.45	.....	4.59	5.50	.....	7.60	.....	4.82

Note.—River frozen January 1 to March 30. From January 1 to about February 20 and March 25 to 30 there was an open channel west of the gage which varied in width during this period from 50 to 180 feet. The river was open about 150 feet below the gage January 1 to February 15 and about 50 feet above the gage throughout the ice period. The following comparative readings were taken:

Mean daily gage height, in feet, of Chippewa River near Eau Claire, Wisconsin, for 1907.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.00	.....	.....	13.47	7.55	7.59	5.73	4.1	3.79	6.34	5.01	4.31
2	6.86	.....	.....	12.25	7.50	7.34	5.77	4.25	1.03	6.89	5.65	3.51
3	4.74	.....	.....	11.05	7.42	7.06	5.79	4.19	4.34	6.12	5.12	3.66
4	4.81	.....	.....	11.03	7.65	6.86	5.6	3.80	4.34	5.61	5.12	3.6
5	4.72	.....	.....	11.65	7.51	6.73	6.47	4.53	4.31	5.72	4.45	3.57
6	4.58	.....	.....	11.48	7.23	6.18	8.34	4.4	4.2	5.56	5.15	4.22
7	4.78	.....	.....	11.19	7.07	6.62	7.89	4.37	4.16	6.46	5.90	4.35
8	4.81	.....	.....	10.38	7.30	6.53	6.76	4.45	3.74	5.60	5.67	3.59
9	4.96	.....	.....	9.93	7.26	6.04	6.33	4.59	4.01	5.28	4.80	4.25
10	5.02	.....	.....	9.51	7.25	6.15	6.04	4.48	4.17	5.37	4.85	4.42
11	4.97	.....	.....	9.59	7.20	6.29	5.4	4.38	4.4	5.45	4.16	4.31
12	4.71	.....	.....	8.73	6.57	5.83	5.18	4.97	4.34	4.79	4.38	4.34
13	4.69	.....	.....	8.59	6.93	5.94	5.12	5.1	4.59	4.59	5.09	4.30
14	5.01	.....	[1]4.90	7.98	7.57	6.13	4.37	4.31	4.04	5.46	4.40	4.16
15	5.20	.....	4.79	8.21	9.18	6.12	5.18	4.19	3.92	5.45	4.44	3.35
16	5.10	.....	5.08	7.66	9.53	6.40	5.88	4.21	4.12	7.04	4.57	3.85
17	5.39	.....	4.86	7.24	9.98	6.39	5.7	4.8	4.49	5.46	4.46	4.20
18	4.80	.....	4.98	7.38	9.46	5.98	4.61	3.8	4.55	4.71	5.20	4.4
19	[1]5.17	.....	5.58	7.19	9.25	6.10	5.05	5.08	8.12	4.60	4.67	4.55
20	.....	.....	5.75	6.82	8.76	5.83	5.32	5.97	12.29	4.70	4.74	3.87
21	.....	.....	6.45	6.48	8.50	5.73	4.57	5.24	13.85	5.26	4.87	4.50
22	.....	.....	6.42	6.86	8.25	5.53	5.48	4.94	12.92	4.84	4.89	3.36
23	.....	.....	7.98	6.27	7.51	5.64	5.45	4.66	11.62	4.66	4.67	3.6
24	.....	.....	8.38	7.10	8.66	6.67	4.98	4.69	10.55	5.49	4.48	4.22
25	.....	.....	10.16	7.17	8.50	6.54	5.12	4.65	9.22	5.35	4.75	3.29
26	.....	.....	12.07	7.31	8.91	6.46	4.81	4.42	8.32	5.17	4.68	4.00
27	.....	.....	13.41	7.32	8.17	6.25	4.64	4.64	8.08	4.40	4.66	3.83
28	.....	.....	14.58	7.11	9.05	5.97	4.68	4.49	8.09	3.96	4.41	3.89
29	.....	.....	14.34	7.22	7.73	5.96	5.04	4.41	7.19	4.65	4.42	3.14
30	.....	.....	15.00	7.11	7.87	5.67	5.26	4.56	7.75	4.65	4.36	3.96
31	.....	.....	15.04	.....	7.66	.....	4.13	4.2	.....	4.68	.....	.....

Comparative water and ice gage readings of Chippewa River near Eau Claire, Wis.

Date.	Water surface.	Top of ice.	Thickness of ice.
1906.			
January 20	4.2	4.8	1.0
January 24	.....	.....	1.1
January 29	4.65	4.95	1.1
February 1	4.9	5.0	1.1
February 5	4.95	5.15	1.2
February 9	5.05	5.25	1.4
February 12	5.2	5.4	1.6
February 15	5.0	5.05	1.7
February 19	5.25	5.35	1.9
February 22	5.1	5.2	1.5
February 26	5.25	5.45	1.3
March 1	5.75	5.8	.9
March 5	5.45	5.5	1.0
March 8	5.15	5.25	.8
March 12	.....	.....	1.5
March 15	4.95	5.05	.9
March 19	4.95	5.05	.9

Fluctuations of daily gage heights during the open period are due almost wholly to "flooding for logs" by lumbermen.

[1] Frozen.

Rating table for Chippewa River near Eau Claire, Wis., from November 30, 1902, to March 12, 1903.[1]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.
3.2	840	4.0	1,965	4.7	3,370	5.4	5,150
3.3	940	4.1	2,165	4.8	3,610	5.5	5,410
3.4	1,055	4.2	2,345	4.9	3,850	5.6	5,670
3.5	1,190	4.3	2,535	5.0	4,110	5.7	5,930
3.7	1,490	4.5	2,940	5.1	4,370	5.8	6,190
3.8	1,655	4.6	3,150	5.2	4,630	5.9	6,450
3.9	1,825			5.3	4,890	6.0	6,710

[1] To be used only when river is frozen.

Rating table for Chippewa River near Eau Claire, Wis., from March 12, 1903, to December 1, 1903.

Gage height.	Discharge	Gage height.	Discharge	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.8	2,160	5.7	6,290	7.6	11,310	11.0	23,310
3.9	2,340	5.8	6,530	7.7	11,610	11.2	24,070
4.0	2,530	5.9	6,770	7.8	11,910	11.4	24,830
4.1	2,730	6.0	7,010	7.9	12,210	11.6	25,500
4.2	2,930	6.1	7,270	8.0	12,510	11.8	26,350
4.3	3,130	6.2	7,530	8.2	13,150	12.0	27,110
4.4	3,330	6.3	7,790	8.4	13,790	12.5	29,010
4.5	3,540	6.4	8,050	8.6	14,450	13.0	30,910
4.6	3,760	6.5	8,310	8.8	15,130	13.5	32,810
4.7	3,980	6.6	8,570	9.0	15,810	14.0	34,710
4.8	4,200	6.7	8,830	9.2	16,530	14.5	36,610
4.9	4,420	6.8	9,090	9.4	17,250	15.0	38,510
5.0	4,640	6.9	9,350	9.6	17,990	15.5	40,410
5.1	4,860	7.0	9,610	9.8	18,750	16.0	42,310
5.2	5,090	7.1	9,890	10.0	19,510	16.5	44,210
5.3	5,330	7.2	10,170	10.2	20,270	17.0	46,110
5.4	5,570	7.3	10,450	10.4	21,030	17.5	48,010
5.5	5,810	7.4	10,730	10.6	21,790	18.0	49,910
5.6	6,050	7.5	11,010	10.8	22,550		

Rating table for Chippewa River near Eau Claire, Wis., from January 1 to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-feet.*
4.0	1,780	5.1	4,390	6.4	8,100	9.0	16,680
4.1	1,980	5.2	4,660	6.6	8,720	9.5	18,380
4.2	2,180	5.3	4,930	6.8	9,350	10.0	20,080
4.3	2,390	5.4	5,200	7.0	9,990	10.5	21,780
4.4	2,610	5.5	5,480	7.2	10,650	11.0	23,480
4.5	2,840	5.6	5,760	7.4	11,310	11.5	25,210
4.6	3,080	5.7	6,040	7.6	11,970	12.0	26,960
4.7	3,330	5.8	6,320	7.8	12,630	13.0	30,500
4.8	3,590	5.9	6,610	8.0	13,290	14.0	34,480
4.9	3,850	6.0	6,900	8.5	14,980	15.0	40,000
5.0	4,120	6.2	7,490				

Rating table for Chippewa River near Eau Claire, Wis., for 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-feet*
3.50	750	5.40	4,830	7.60	10,290	11.40	22,410
3.60	960	5.50	5,050	7.80	10,870	11.60	23,160
3.70	1,170	5.60	5,280	8.00	11,450	11.80	23,950
3.80	1,380	5.70	5,510	8.20	12,080	12.00	24,750
3.90	1,590	5.80	5,740	8.40	12,610	12.20	25,550
4.00	1,800	5.90	5,970	8.60	13,200	12.40	26,350
4.10	2,010	6.00	6,200	8.80	13,800	12.60	27,150
4.20	2,220	6.10	6,430	9.00	14,400	12.80	27,950
4.30	2,430	6.20	6,660	9.20	15,000	13.00	28,750
4.40	2,640	6.30	6,900	9.40	15,620	13.20	29,560
4.50	2,850	6.40	7,140	9.60	16,260	13.40	30,390
4.60	3,070	6.50	7,380	9.80	16,920	13.60	31,240
4.70	3,290	6.60	7,630	10.00	17,600	13.80	32,110
4.80	3,510	6.70	7,880	10.20	18,280	14.00	33,000
4.90	3,730	6.80	8,130	10.40	18,960	14.20	33,900
5.00	3,950	6.90	8,390	10.60	19,640	14.40	34,800
5.10	4,170	7.00	8,650	10.80	20,320	14.60	35,700
5.20	4,390	7.20	9,180	11.00	21,000	14.80	36,600
5.30	4,610	7.40	9,720	11.20	21,690		

Rating table for Chippewa River near Eau Claire, Wis., for 1906.

3.50	1,040	4.90	3,820	6.30	7,360	8.40	13,600
3.60	1,210	5.00	4,050	6.40	7,640	8.60	14,240
3.70	1,390	5.10	4,280	6.50	7,920	8.80	14,890
3.80	1,570	5.20	4,520	6.60	8,200	9.00	15,550
3.90	1,760	5.30	4,760	6.70	8,480	9.20	16,210
4.00	1,950	5.40	5,000	6.80	8,770	9.40	16,890
4.10	2,140	5.50	5,250	6.90	9,060	9.60	17,570
4.20	2,340	5.60	5,500	7.00	9,350	9.80	18,250
4.30	2,540	5.70	3,760	7.20	9,930	10.00	18,950
4.40	2,740	5.80	6,020	7.40	10,530	11.00	22,550
4.50	2,950	5.90	6,280	7.60	11,130	12.00	26,350
4.60	3,160	6.00	6,550	7.80	11,730	13.00	30,350
4.70	3,380	6.10	6,820	8.00	12,350	14.00	34,500
4.80	3,600	6.20	7,090	8.20	12,970	15.00	38,750

Note.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1902-1906. It is well defined between gage heights 4 feet and 15 feet.

Estimated monthly discharge of Chippewa River at Eau Claire, Wis., 1902 to 1906.

[Drainage area, 6,740 square miles.]

Date.	Discharge.			Run-off.		Rainfall.[1]
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
1902.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Inches.	Inches.
November 14-29	.....	.....	14,885	2.20	1.39	5.82
December 5-31	.....	.....	2,789	.41	.41	1.92

[1] Rainfall for 1902 and 1905 is the average of the recorded precipitation at the following stations: Butternut, Hayward, Medford, Barron, Eau Claire; that for 1904 includes the same stations with the addition of Stanley and Prentice.

Estimated monthly discharge of Chippewa River at Eau Claire, Wis., 1902 to 1906—Continued.

Date.	Discharge.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
1903.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*
January	3,730	1,190	2,593	.38	.44	.45
February	2,940	995	2,023	.30	.31	.86
March	34,520	840	11,573	1.72	1.98	2.28
April	25,970	8,050	11,240	1.67	1.86	3.07
May[1]	44,970	11,460	24,761	3.67	4.23	6.45
June[2]	36,990	2,070	8,720	1.29	1.44	1.95
July	39,650	4,750	14,698	2.18	2.51	7.70
August	23,500	3,960	8,602	1.28	1.48	5.35
September	51,810	6,170	19,584	2.90	3.24	7.58
October	25,780	6,770	13,524	2.01	2.32	3.57
November	5,930	2,830	4,562	0.68	0.76	0.86
December	3,960	1,055	2,855	.42	.48	.84
The year	51,810	840	10,395	1.54	21.05	41.77
January	.....	.....	.....	.....	.....	.51
February	.....	.....	.....	.....	.....	1.05
March 19-31	8,255	1,920	4,622	.686	.332	1.56
April	22,220	7,640	14,550	2.16	2.41	2.01
May	32,900	7,700	16,960	2.52	2.90	4.33
June	24,510	4,390	12,600	1.87	2.09	6.14
July	21,170	1,647	8,525	1.26	1.45	3.13
August	13,790	650	3,778	.561	.647	4.27
September	19,430	2,264	7,801	1.16	1.29	4.86
October	40,400	3,642	15,170	2.25	2.59	5.59
November	9,478	2,748	5,576	.827	.923	.17
December 1-27	2,960	380	2,230	.331	.382	1.79
The year	.....	.....	.....	.....	.....	35.41
1905.						
March 18-31	.....	31,240	2,640	13,510	2.00	1.04
April	.....	24,750	3,510	10,184	1.51	1.68
May	.....	28,350	5,740	12,666	1.88	2.17
June	.....	60,520	5,625	20,368	3.02	3.26
July	.....	22,050	2,535	8,626	1.28	1.48
August	.....	14,100	2,535	5,867	.870	1.00
September	.....	20,320	3,730	8,970	1.33	1.48
October	.....	14,250	3,510	8,041	1.19	1.37
November	.....	7,380	3,070	5,437	.807	.900
December	.....	5,970	2,010	3,821	.567	.654
1906.						
April	38,100	10,400	24,900	3.69	4.12	.....
May	22,700	6,770	13,500	2.00	2.31	.....
June	20,000	3,820	10,000	1.48	1.65	.....
July	13,700	1,140	5,350	.794	.92	.....
August	19,600	1,330	6,220	.923	1.06	.....
September	17,400	2,910	6,970	1.03	1.15	.....
October	15,900	1,120	6,270	.930	1.07	.....
November	10,600	4,570	8,310	1.24	1.38	.....
December	9,090	2,700	4,810	.714	.82	.....
1907.						
January	a8,900	3,000	4,025	0.597	0.688	.....
February	b.....	.....	.....	.....	.....	.....
March	c39,000	3,750	15,150	2.28	2.63	.....
April	31,100	7,200	14,675	2.17	2.42	.....
May	18,700	8,075	12,600	1.87	2.16	.....
June	11,190	5,300	7,225	1.07	1.19	.....
July	12,150	2,050	5,300	.786	.907	.....
August	6,400	1,400	2,800	.415	.478	.....
September	32,000	1,275	7,700	1.18	1.32	.....
October	8,200	1,750	4,550	.676	.78	.....
November	6,250	2,150	3,600	.539	.597	.....
December	3,200	400	1,675	.248	.286	.....

[1] May 31 estimated.
[2] 1 to 6, inclusive, estimated.

Note.—Values for 1906 are excellent. During January, February, and March the flow probably seldom exceeded 3,000 second-feet and may have attained a minimum of 1,500 second-feet, or less.

a For first 19 days. b Frozen. c For last 18 days only.

Rating table for Chippewa River near Eau Claire, Wis., for 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
3.50	1,040	4.90	3,820	6.30	7,360	8.40	13,600
3.60	1,210	5.00	4,050	6.40	7,640	8.60	14,240
3.70	1,390	5.10	4,280	6.50	7,920	8.80	14,890
3.80	1,570	5.20	4,520	6.60	8,200	9.00	15,550
3.90	1,760	5.30	4,760	6.70	8,480	9.20	16,210
4.00	1,950	5.40	5,000	6.80	8,770	9.40	16,890
4.10	2,140	5.50	5,250	6.90	9,060	9.60	17,570
4.20	2,340	5.60	5,500	7.00	9,350	9.80	18,250
4.30	2,540	5.70	5,760	7.20	9,930	10.00	18,950
4.40	2,740	5.80	6,020	7.40	10,539	11.00	22,550
4.50	2,950	5.90	6,280	7.60	11,130	12.00	26,350
4.60	3,160	6.00	6,550	7.80	11,730	13.00	30,350
4.70	3,380	6.10	6,820	8.00	12,350	14,00	34,500
4.80	3,600	6.20	7,090	8.20	12,970	15.00	38,750

Note.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1902-1906. It is well defined between gage heights 4 feet and 15 feet.

CHIPPEWA RIVER AT CHIPPEWA FALLS, WIS.

The United States Weather Bureau has maintained a station at this point since 1900. June 1, 1906, the U. S. Geological Survey began making discharge measurements at the highway bridge, 2,500 feet below the dam at Chippewa Falls.

The channel is straight for 500 feet above the station and for a considerable distance below. The left bank is low and liable to overflow; the right bank is formed by a railroad embankment, which is under water in high floods. The bed of the stream is gravel and sand and is probably permanent. The current is swift.

Discharge measurments are made from the lower side of the steel highway bridge. The initial point for soundings is the inner face of the right abutement at the downstream side. The gage is an iron staff attached to the downstream face of the first pier from the right bank. The gage readings for 1906 were furnished by N. O. Swift, the United States Weather Bureau observer at Chippewa Falls. The river stage during the "sawing season" fluctuates very rapidly at times, due to the storage of water at Holcombe by the lumber company. This reservoir is opened two or three times a week to flood logs to the sawmill. A measurement was made at this station on June 1. 1906, by M. S. Brennan, giving the following results:

Width, 721 feet; area, 4,700 square feet; gage height, 6.70 feet; discharge, 18,000 second-feet.

Daily gage height, in feet, of Chippewa River at Chippewa Falls, Wis., for 1905.

Day.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.0	4.0	8.2	2.0	1.7	2.3	1.5	3.9	3.0
2	.....	4.3	4.0	2.3	1.8	1.5	1.4	1.8	3.6	2.7
3	.....	5.5	4.2	5.0	2.4	1.0	1.5	3.0	3.4	2.4
4	.....	6.3	4.4	4.0	2.3	1.4	4.6	1.8	3.2	2.2
5	.....	8.0	5.0	3.1	2.0	1.3	1.8	1.5	3.1	2.0
6	.....	7.9	5.1	3.6	2.4	1.5	1.5	1.3	3.0	1.9
7	.....	7.8	5.4	3.1	2.3	3.0	1.8	1.2	3.0	1.8
8	.....	8.0	4.5	5.1	1.0	1.9	1.5	1.0	3.0	1.8
9	.....	9.0	2.5	6.0	1.5	[illegible]	1.4	1.2	3.8	1.8
10	.....	9.8	2.3	5.6	2.0	2.4	2.4	1.2	3.8	1.8
11	.....	9.9	2.0	5.1	2.3	1.5	1.5	3.3	3.6	1.8
12	.....	9.5	1.8	5.0	1.5	1.3	1.6	1.3	3.4	1.9
13	.....	9.6	2.3	4.0	1.6	1.9	1.7	1.3	3.3	2.0
14	.....	10.0	2.9	3.9	1.5	1.2	1.8	1.4	3.2	2.0
15	.....	11.5	5.8	3.5	2.0	1.7	3.0	1.5	2.7	2.0
16	.....	11.4	5.0	3.3	2.4	1.4	3.2	1.7	2.6	2.0
17	.....	10.5	2.3	2.3	2.7	1.3	6.5	1.8	2.5	2.0
18	.....	9.3	4.3	3.5	1.8	1.4	3.6	1.8	2.8	2.0
19	.....	8.8	4.4	1.8	2.0	1.3	2.6	1.5	3.3	2.0
20	.....	7.4	2.9	1.5	1.9	1.2	2.8	1.5	3.0	2.0
21	.....	8.[illegible]	3.0	1.9	1.7	1.5	2.5	1.7	2.8	2.0
22	.....	7.8	1.8	2.0	1.1	1.8	2.8	2.0	2.7	2.0
23	.....	7.4	4.0	2.4	1.8	4.0	3.0	2.3	2.5	2.0
24	.....	7.0	5.7	1.0	1.0	1.8	6.8	2.4	2.2	2.0
25	.....	7.3	2.4	1.5	1.8	4.5	3.8	3.0	2.0	2.0
26	.....	6.3	3.8	2.5	1.5	2.8	3.5	5.1	2.2	2.0
27	.....	5.6	5.5	2.7	1.6	4.2	2.5	5.0	2.5	2.0
28	.....	5.0	6.6	2.8	1.5	1.8	2.3	5.0	3.0	2.0
29	.....	4.4	6.8	3.3	1.2	2.7	2.5	4.9	3.3	2.0
30	.....	4.2	5.9	1.0	1.0	1.5	2.4	4.6	3.4	2.0
	3.6	.....	5.7	.....	1.5	1.3	.....	3.8	.....	2.0

Note.—There were ice conditions January 1 to March 31; also December 13 to 31.

Mean daily gage height, in feet, of Chippewa River at Chippewa Falls, Wis., for 1907.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	9.5	3.9	4.0	2.2	1.0	.8	2.0	1.3	.9
2	.....	8.0	4.0	3.9	2.1	1.1	.9	1.7	1.4	.9
3	.....	7.5	3.9	3.5	2.2	1.2	.8	1.9	1.4	.9
4	.....	7.3	4.2	3.4	2.3	1.0	.7	1.7	1.4	.9
5	.....	8.0	4.0	3.3	3.2	1.2	.8	1.8	1.3	.9
6	.....	7.9	3.9	2.5	3.5	1.3	.7	2.8	1.4	1.0
7	.....	7.5	3.8	3.0	2.9	1.2	.8	2.8	1.5	1.0
8	.....	6.9	3.9	3.3	2.4	1.3	.7	1.5	1.3	1.0
9	.....	6.6	3.8	2.7	2.3	1.2	.6	1.4	1.1	1.0
10	.....	5.5	3.7	2.5	2.1	1.3	.7	1.5	1.1	1.0
11	.....	5.4	3.8	2.7	2.2	1.2	.8	1.3	1.3	1.0
12	.....	5.0	3.5	2.9	1.9	1.1	.9	1.3	1.3	1.0
13	.....	5.2	3.4	2.4	1.7	1.3	.8	1.3	1.3	1.0
14	.....	4.4	3.7	2.5	1.6	1.1	.7	1.7	1.4	1.0
15	.....	4.3	5.5	2.8	1.4	1.0	.8	1.7	1.4	1.0
16	.....	4.2	5.9	2.7	1.5	1.1	.9	1.8	1.4	1.0
17	.....	3.9	6.6	2.6	1.6	1.0	1.0	1.5	1.5	1.0
18	1.8	3.8	6.5	2.4	1.4	.9	1.1	1.3	1.4	1.0
19	1.7	3.6	6.0	2.5	1.6	1.0	4.0	1.3	1.4	1.0
20	2.2	3.5	5.3	2.3	1.7	1.2	8.3	1.4	1.4	1.0
21	2.3	3.4	5.2	2.2	1.3	1.3	10.0	1.5	1.3	1.0
22	2.5	3.3	4.8	2.1	1.2	1.2	9.5	1.5	1.4	.9
23	3.5	2.9	4.5	2.2	1.8	1.1	8.4	1.5	1.3	.9
24	4.0	2.8	4.3	2.4	1.6	1.0	7.3	1.5	1.2	.9
25	4.5	3.6	4.7	3.4	1.5	1.1	4.3	1.3	1.2	.9
26	6.5	4.0	4.9	3.0	1.3	1.0	6.9	1.1	1.1	.9
27	7.0	3.8	4.4	2.7	1.2	.9	4.2	1.1	1.1	.9
28	9.0	3.9	4.7	2.6	1.1	1.0	4.7	1.1	.1	.9
29	10.0	3.8	3.5	2.4	1.0	.9	2.7	1.1	.1	1.0
30	11.0	4.0	4.0	2.3	1.7	.8	4.4	1.2	.9	1.0
31	10.9	.....	4.1	.....	1.0	.9	.....	1.3	.....	1.0

Note.—River frozen to March 18.

Discharge measurements of Chippewa River at Chippewa Falls in 1907.

Day.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	*Sq.-feet.*	*Ft. per sec.*	*Feet.*	*Sec.-feet.*
1907.						
April 2	A. H. Horton	724	5,624	4.47	7.88	25,166
June 19	G. A. Gray	565	1,793	2.84	2.4	5,094
July 19	do	481	1,323	2.27	1.35	3,066
August 21	do	479	1,127	1.78	1.0	2,033
September 21	do	755	7,188	4.30	9.95	30,951
September 23	do	728	5,704	4.06	7.9	23,209
September 24	do	698	4,948	3.95	6.9	19,583
September 25	do	662	3,275	3.83	4.47	12,560
September 26	do	660	3,532	3.73	4.9	13,070
October 19	do	487	1,323	2.22	1.35	2,939
November 15	do	413	1,013	2.75	1.4	2,790
December 20	do	432	992	1.69	.8	1,540

Discharge measurements under ice of Chippewa River at Chippewa Falls, Wis., in 1908.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height. Water sur.	Discharge	Av. th. of ice.	Depth of snow.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.		
1908.								
January 23	G. A. Gray	470	714	1.93	0.8	1,377	0.9	No.
February 14	do	487	821	2.03	1.1	1,668	1.5	No.

Average thickness of ice, 1908.

Date.		Feet.
Jan. 3.	Average thickness of ice	.5
Jan. 10.	do	1.1
Jan. 17.	do	1.2
Jan. 24.	do	1.5
Jan. 31.	do	1.3
Feb. 7.	do	1.6
Feb. 14.	do	1.5
Feb. 21.	do	1.4
Feb. 28.	do	.9
Mar. 8.	do	.9
Mar. 16.	do	.8
Mar. 22.	River open.	

Water Powers.

CHIPPEWA BELOW JUNCTION OF FLAMBEAU RIVER.

Topography and Drainage.—The following descriptions of the water powers on Chippewa River between its mouth and the junction with Flambeau River were largely obtained from a manuscript report of a hypsometric survey of this part of the river made by the United States Geological Survey during the summer of 1903.[1] Between the mouth of the river and Chippewa Falls a very careful primary level was run, while between Chippewa Falls and the mouth of the Flam-

[1] The survey of that portion of the river between Watkins Landing, Minnesota, and Chippewa Falls, Wis., was under the charge of Geographer J. H. Renshaw. Above Chippewa Falls the work was in charge of Geographer H. M. Wilson.

beau, in addition to taking levels, a topographic survey was made of the river bank and the area immediately adjacent. Between the mouth of the Chippewa and that of the Eau Claire, a distance of 48.4 miles, this survey showed that there was a descent at low water of about 106 feet, or about 2.3 feet per mile. Because of the uniformity of this low gradient, and also because of the width of the stream and of the adjacent bottom lands, there are no opportunities for water powers until Eau Claire is reached. Details of descent and apportionment of drainage areas are shown in the following tables:

Profile of Chippewa River from its mouth to sources of East and West branches.[1]

No.	Station.	Distance.		Elevation above sea-level	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet.*
	Reeds Landing	0	0	[2]680.0 [3]664.0	.....	0
2	Shawtown	45.5	45.5	770.0	106.0	2.3
3	Eau Claire River, mouth	48.8	3.3	770.0	.0	.0
	Dalles paper mills:					
4	Foot of dam	49.4	.6	772.0	2.0	3.3
5	Head of dam	49.4	10.0	793.0	21.0	.....
	Chippewa Falls:					
6	Foot of dam	64.4	14.5	806.0	14.0	1.0
7	Head of dam	64.4	50.0	839.0	33.0	.....
8	Yellow River, mouth	69.9	5.5	852.0	13.0	2.4
	Eagle Rapids:					
9	Foot	72.4	2.5	854.0	2.0	.8
10	Head	73.6	1.2	867.0	13.0	10.8
11	Water level	75.1	1.5	871.0	4.0	2.7
12	Rapids, foot	77.4	2.3	881.0	10.0	4.3
	Jim Falls:					
13	Foot	80.1	2.7	901.0	20.0	7.4
14	Head	81.0	.9	936.0	35.0	39.0
	Colton Rapids:					
15	Foot	82.3	1.3	942.0	6.0	4.6
16	Head	83.6	1.3	945.0	3.0	2.3
17	Bob Creek	87.3	3.7	954.0	9.0	2.4
	Chevalley rapids:					
18	Foot	90.1	2.8	961.0	7.0	2.5
19	Head	91.3	1.2	966.0	5.0	4.2
	Brunett Falls:					
20	Foot	91.4	.1	967.0	1.0	10.0
21	Head	92.4	1.0	993.0	26.0	26.0
22	Fisher River, mouth	93.9	1.5	995.0	2.0	1.3
	Holcombe rapids:					
23	Foot	97.1	3.2	1,004.0	9.0	2.7
24	Foot of dam	97.6	.5	1,020.0	16.0	32.0
25	Head of dam, water level	97.6	.0	1,036.0	16.0	.....
26	Deertail Creek, mouth	104.1	6.5	1,036.0	.0	.0
27	Flambeau River, mouth of	107.7	3.6	1,050.0	14.0	4.0
28	Bruce, sec. 28, T. 32 N., R. 6 W.	124.2	16.5	1,064.0	14.0	0.85

[1] Authority: Nos. 1, Mississippi River Commission; 2-27, U. S. Geol. Survey; 28, 29 Ry. 30-47 U. S. engineers.
[2] High water.
[3] Low water.

Profile of Chippewa River from its mouth to sources of East and West branches—Continued.

No.	Station.	Distance. From mouth.	Distance. Between points.	Elevation above sea-level.	Descent between points. Total.	Descent between points. Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
29	N. E. ¼, N. E. ¼, S. 23, T. 36 N., R. 7 W., Wis. Cent. Ry	135.2	11	1,112.0	48.0	4.4
30	East and West branches junction	162.7	27.5	1,260.0	168.0	6.1
	EAST BRANCH.					
31	Goose Eye rapids head (foot Little Chief Lake)	164.7	2.0	1,323.4	43.4	21.7
	Snaptail rapids (Hunters Lake):					
32	Foot	166.7	2.0	1,325.2	1.8	.9
33	Head	168.2	1.5	1,368.8	43.6	29.0
34	Blaisdells Lake	170.7	2.5	1,374.5	5.7	2.3
	Cedar rapids:					
35	Foot	173.2	2.5	1,404.0	29.5	11.8
36	Head	175.7	2.5	1,420.0	16.0	6.4
37	Bear Lake	178.2	2.5	1,432.9	12.9	5.1
38	River, water level	181.7	3.5	1,442.0	9.1	2.6
39	Pelican Lake	186.7	5.0	1,462.0	20.0	4.0
40	River, water level, sec. 19, T. 42 N., R. 2 W.	190.2	3.5	1,463.8	1.8	.5
41	Glidden Station	201.7	11.5	1,509.3	45.5	4.0
42	Source of river	223.7	22.0±	.....	.....	.....
	WEST BRANCH.					
43	Proposed U. S. dam	164.5	1.8	1,286.0	6.0	3.3
44	Pakaawang Lake	166.7	6.0	1,287.2	1.2	.2
	Moose Lake:					
45	Proposed U. S. Dam	178.7	10.0	1,358.8	71.6	7.2
46	Water level	178.7	.0	1,361.9	3.1	.....
47	Partridge Crop Lake	185.7	7.0	1,384.4	22.5	3.2
48	Source of river	205.7	20.0±	.....	.....	.....

Distances and drainage areas of Chippewa River.

River.[1]	Distance from the junction of East and West branches, map measure	Drainage area above station.
	Miles.	Sq. miles.
East and West branches (junction)	0	757
Court Oreilles	14	988
Thornapple (above mouth)	36	1,383
Flambeau:		
Above mouth	53	1,777
Mouth	53	3,761
Yellow:		
Above mouth	90	4,926
Mouth	90	5,384
Eau Claire:		
Above mouth	113	5,760
Mouth	113	6,659
Red Cedar:		
Above mouth	142	7,004
Mouth	142	8,961
Chippewa	165	9,573

[1] Station is at mouth of river, unless otherwise stated.

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Fig. 1. THE DELLS PAPER AND PULP CO.'S DAM AND MILL, EAU CLAIRE, WIS.

Fig. 2. BRUNETTE FALLS, CHIPPEWA RIVER.

WATER POWERS.

Eau Claire.—The first dam site is located about 2½ miles below the mouth of Eau Claire River. According to a recent survey by the city engineer, a head of 7 feet could be obtained here. On account of its proximity to the city of Eau Claire, this power would have especial value. Before improvement there were two rapids in the river between Eau Claire and Chippewa Falls, one 1.25 miles above the Eau Claire, called the Lower Dalles, with a descent of 10.5 feet in a little over 2 miles; the other about 4 miles below Chippewa Falls, called the Upper Dalles, with a descent of 9 feet in about 2 miles.

The dam 2 miles above Eau Claire, owned by the Dells Paper and Pulp Company, is of the square-timber, crib type on a sandstone foundation. It is about 600 feet long, 19 feet high, 3 feet wide at the top, and with a base of about 8 feet. Eight splash boards are used on the crest when necessary, giving a head of 26 feet. It would be possible to increase the height of the dam so as to develop 32 feet, and a bill authorizing this increase is now (March, 1907) pending before the State legislature. Such a dam would back the water nearly to Chippewa Falls, 15 miles above, greatly adding to an already very large pondage. This is the most important manufacturing plant on the river. The turbine installation is reported as follows:

Dells Paper and Pulp Company's turbine installation, 2 miles above Eau Claire.

Purpose.	Horsepower.
Paper mill	1,396
Pulp mill	4,918
Electric light and power	1,632
Waterworks	300
	8,246

A view of this plant is shown in Plate XXXVI.

Chippewa Falls.—In the 14.5 miles between the Dells dam and Chippewa Falls no power sites are found, the river having a nearly uniform slope of 1 foot to the mile. At the latter place, however, is a wooden dam 800 feet long, with a head of 30 feet, owned by the Chippewa Falls Lumber and Boom Company. This dam supplies power for a large sawmill and also a plant furnishing the city of Chippewa Falls with water and electric light. The dam could be made several feet higher, as the local conditions are favorable, but this

would interfere with a proposed plant at Paint Creek rapids, 2.5 miles upstream, to which point the water now backs. The owners have developed only about 20 feet of head, but this could be increased to the full head of 30 feet by blasting and cleaning out the river to the wagon bridge below. The power and light company leases 1,000 horsepower, using a head of 29 feet. A view of this dam is shown in Plate XXXVII.

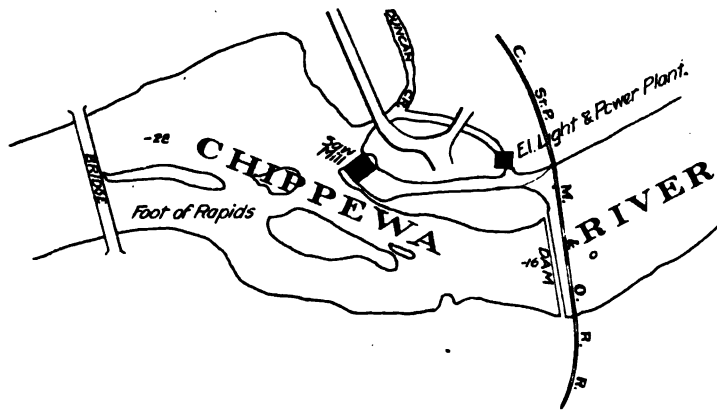

Fig. 11.—Chippewa River at Chippewa Falls.

Paint Creek.—The next rapids, known by this name, are 2.5 miles above the Chippewa Falls dam. A flooding dam 526 feet long, with a crest 10.5 feet above low water, was formerly maintained here. A dam about 800 feet long, with a head of 14 feet, could be constructed at the foot of the rapids at this point. The banks and bed appear to be sand, intermingled with large bowlders. Stone for construction is abundant and near at hand, and it is likely that a rock foundation could be easily obtained.

Eagle Rapids, 4.5 miles farther upstream, in lot 3, sec. 16, T. 29 N., R. 8., is a good site for a dam, owned by F. G. & C. A. Stanley. of Chippewa Falls. A dam 60 feet long and 20 feet high would back the water three-fourths of a mile above the city of Chippewa, where O'Neil's Creek enters from the west. One mile above the mouth of O'Neils Creek, in Sec. 10, T. 29 N., R. 8 W., is a gorge 700 feet wide, where a 25-foot dam would have solid sandstone for foundations and abutments and would back the water almost to the foot of Jim Falls, 5 miles above. Such a dam would develop 5,000 theoretical horsepower.

DAM AT CHIPPEWA FALLS, WISCONSIN. HIGH WATER.
Head, 20 feet.

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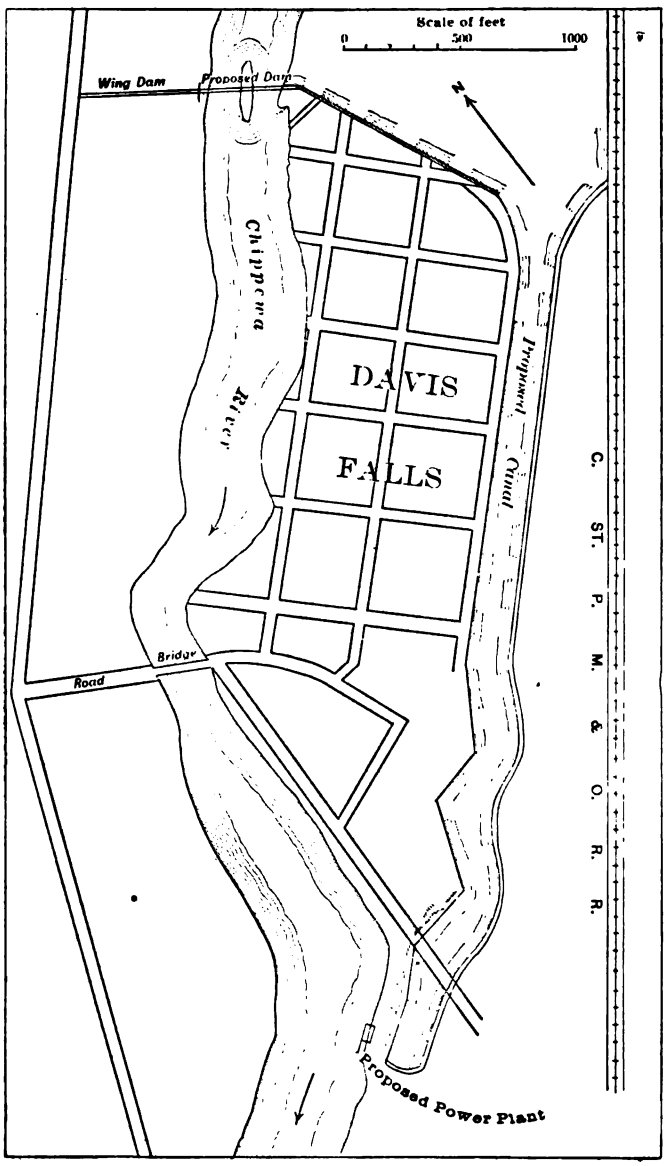

Fig. 12.—Map of proposed waterpower development on the Chippewa River at Davis Falls, Wis.

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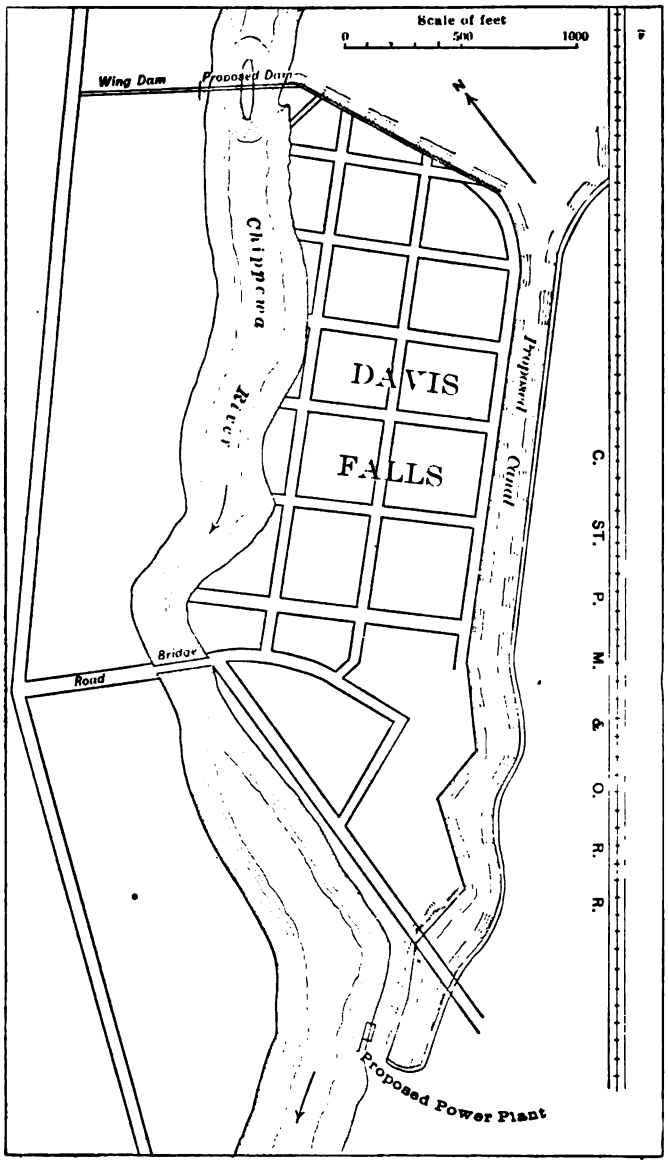


Fig. 12.—Map of proposed waterpower development on the Chippewa River at Davis Falls, Wis.

Davis Falls.—Near the small station of Jim Falls, on the Chicago and Northwestern Railway, occurs the best opportunity for water-power development on Chippewa River. It is owned by W. L. Davis, of Eau Claire. Formerly an old flooding dam was located here. The river flows over a series of granite ledges 1 to 4 feet high, while the banks seem to be of the same rock, covered by a few feet of sandy soil. This power is now under development, a company having purchased all the land needed. The proposed dam, 28 feet high, will be located at the head of the rapids. It is designed to furnish power for a pulp mill near the foot. The total head obtained by this plant will be 55 feet. Fig. 12 shows the plan of the proposed deveopment. Water is to be conducted from the dam by a canal extending on the left bank for a distance of about 5,000 feet to high bluffs 100 feet from the river bank. The power house will be on the river bank immediately below. The dam will back the water nearly to Brunett Falls, 9.5 miles above, and will cover the Colton and Chevalley rapids.

Burnett Falls.—One of the best powers on Chippewa River, and one most cheaply developed, is found at Burnett Falls (Pl. XXXVI), located in Sec. 18, T. 31 N., R. 6 W. It belongs to Cornell University, which also owns the adjacent land as well as the water rights. The best location for the dam would be about 650 feet above the foot of the rapids, where a 35-foot dam would back the water up to the rapids at Holcombe, 5½ miles above. The river at the dam site is narrow (70 or 80 feet), while the banks are high, granite ledges. A dam here would create a large reservoir. It is stated that the plans contemplate a dam 200 feet long. A steel wagon bridge has recently been built across the river immediately below the dam site.

Holcombe Dam.—The next power is at Holcombe, about 3 miles below the mouth of Jump River, where the Chippewa Falls Lumber and Boom Company mantains a timber dam, with a head of about 17 feet. This is the third dam that has been built here, the others having been washed out by freshets. As the lumber interests are fast declining, the present dam is being allowed to decay. For power purposes it should be replaced by a more substantial structure. The river here has a rock bottom, with rather low clay sides, but an 18-foot dam could be constructed on the site of the present structure, which, together with a 15-foot dam at the foot of the rapids just below (sometimes called Little Falls), would develop about all the head at this

point and would not flood any more valuable lands above. This would back the water above Deertail Creek and furnish considerable storage.

Mouth of Flambeau.—Of the 14 feet of descent in Chippewa River between Holcombe and the mouth of the Flambeau 10 feet are concentrated in the first mile below the latter point. It is very likely that a dam on this reach would easily develop 15 feet of head.

It is worthy of note that all the water powers on Chippewa River thus far described are reached by one or more railroads. Because of their availability many of the above powers are likely to be developed in the near future. Their importance is emphasized by the following statement: Of the 244 feet descent in the Chippewa between Chippewa Falls of the Flambeau, 116 feet are concentrated in 5 falls and rapids. The building of 10 dams would economically develop a total of 213 feet head in this distance of 43 miles. When fully developed these powers will rival in importance the extensive developments on lower Fox River between Appleton and Green Bay.

BRANCHES AND UPPER WATERS.

Topography and Drainage.—The following statements in regard to the water powers of upper Chippewa River, not being based on a hydrographic survey, are necessarily incomplete. Statements concerning profile, etc., are based on the survey and maps of this region made in 1880 by United States engineers in connection with the reservoir surveys. Distance and drainage area data are shown in the following table:

Length and drainage area of the upper tributaries of Chippewa River.

River.	Length (map measure.	Drainage area.
	Miles	Sq. miles.
West Branch of Chippewa	35	480
East Branch of Chippewa	60	278
Court Oreilles	20	176
Flambeau	155	1,983
Jump	65	721
Yellow	65	458
Eau Claire	65	899
Red Cedar	95	1,957

In the 16.5 miles between the mouth of the Flambeau and Bruce, Chippewa River descends only 0.8 foot per mile, but in the 38.5 miles between Bruce and the confluence of East and West branches

of the Chippewa, in Sec. 2, T. 39 N., R. 6 W., the river descends 216 feet, an average of 5.6 feet per mile. This steep gradient is certain to produce many good powers. This reach is, however, devoid of railroads except a few logging roads. One of these undeveloped powers, called Belills Falls, is located in Sec. 26, T. 38 N., R. 7 W. Its owner, the John Arpin Lumber Company, reports that this power is capable of producing a head of about 30 feet. It is near Radison, on the Chicago, St. Paul, Minneapolis and Omaha Railway.

East Branch of Chippewa.—Three important rapids occur in East Branch of Chippewa River Between Little Chief Lake and the confluence of East and West branches, a distance of 2.7 miles, there is a descent of 43 feet. Between these points there is a series of rapids, "the bed of the river being literally paved with bowlders. The banks are from 10 to 20 feet high and the drift a reddish clay." These are known as the Goose Eye rapids. Two or three dams could develop a head of about 40 feet.

Above Hunters Lake, in Secs. 22 and 23, T. 40 N. R. 5 E., occur the Snaptail Rapids with an aggregate descent of 43.6 feet.

Cedar Rapids, the last of importance on this branch, with a descent of 16 feet, are located in Sec. 9, T. 40 N., R. 4 W., and in the 2 miles above. The total descent between Blaisdell and Bear Lakes is about 58 feet, all in a distance of 7.5 miles. Between Bear and Little Chief Lakes the banks vary from 4 to 50 feet in height. A logging dam has been maintained at the head of the rapids, in Sec. 26, T. 41 N., R. 4 W., which had a height of 10 feet. Measurements made here by United States engineers on June 20 and July 12, 1879, with the river respectively 0.6 and 2.1 feet above low-water mark, showed a discharge of 381 and 472 second-feet. The river at this point is 153 feet wide.

West Branch of Chippewa.—West Branch of the Chippewa River has a drainage area of 480 square miles, or 200 square miles more than East Branch, but its descent is considerably less rapid. The river has its source in several large lakes at about 1,380 feet above sea level. The first undeveloped power is located about 1.5 miles above the confluence of the two branches, in Sec. 34, T. 40 N., R. 6 W., where the hills approach within 900 feet. The river at this point has a width of 121 feet, and here United States engineers made surveys for a dam with a head of 25.5 feet, which gave a very large reservoir area. A 15-foot head could probably be obtained at reasonable expense. Four measurements made by United States engineers

on August 6, 1779, at a stage only 0.2 foot above low water gave a mean discharge of 360 second-feet, of 0.75 second-feet per square mile of drainage area. This large low-water run-off is double that estimated for this drainage area. The excess may be explained by the steadying action of the large lakes near the headwaters of this river.

In the 10 miles between Moose and Pakwawang Lakes West Branch descends 71.6 feet, including a series of rapids with sluggish water between. The banks are generally from 20 to 30 feet high, with clay soil.[1]

Court Oreilles River.—Court Oreilles River has its source at an elevation of 1,287 feet in a lake of the same name. The group of lakes forming its headwaters have a total area of about 16 square miles. A dam at this outlet would need to have a length of 260 feet to secure a head of 5 feet, and would store a supply sufficient to deliver 255 second-feet for ninety days at times of low water. The river is from 50 to 60 feet wide, and in the first 3 miles of its course is sluggish. Thence to its mouth it furnishes a series of rapids, with still reaches between. The most important rapids known as the Court Oreilles, are situated within 3 miles from the mouth of the river, which at this point flows over ledges of the pre-Cambrian rocks. The river is crossed at its middle point by the Chicago, St. Paul, Minneapolis and Omaha Railway, where the water surface has an elevation of 1,240 feet. This shows a descent of 47 feet in 10 miles between this point and the lake. The lower half of the river is reached by the above railway. Unlike either East Branch, West Branch, or any other neighboring branches of the Chippewa, Court Oreilles River drains a region with a very open sandy soil. A measurement made by United States engineers, October 25, 1879, at a stage 0.3 foot above low water, showed a discharge at the mouth of Lake Court Oreilles of only 28 second-feet from a drainage area of 114 square miles. It seems likely that, because of the character of the soil, part of the run-off escapes underground to the west into Namekagon River.

Upper Powers.—Because of their present isolation from railroads, the chief use of dams which have been maintained on the upper headwaters of Chippewa River would lie in their operation as reservoirs to improve the powers below. Their location is shown in the following table:

---

[1] Rept. Chief Eng. U. S. Army, 1880, p. 1562.

Dams on upper waters of Chippewa River.[1]

No.	Location.	Dimensions[2]		Reservoir capacity.
		Height.	Length.	
	Chippewa River:	Feet.	Feet.	Cubic feet.
	Chippewa River:			
1	NW. ¼ sec. 28, T. 32 N., R. 6 W.	21	625	133,333,000
2	Sec. 22, T. 33 N., R. 8 W.	9	.....	153,331,000
3	Sec. 28, T. 32 N., R. 6 W.	17	.....	334,536,000
	West Branch:			
4	SW. ¼ SW. ¼ sec. 32, T. 42 N., R. 5 W.	8	123	.....
5	Sec. 12, T. 42 N., R. 5 W.	*20	*300	.....
6	NE. ¼ SE. ¼ sec. 14, T. 41 N., R. 6 W.	7	347	430,000,000
7	Outlet to Pokegama Lake, NW. ¼, NW. ¼ sec. 32, T. 40 N., R. 6 W.	8	108	.....
8	Little Chief River, NE. ¼ NE. ¼ sec. 26, T. 40 N., R. 7 W.	6	142	.....
9	East Branch, NW. ¼ SE. ¼ sec. 26, T. 41 N., R. 4 W.	10	564	300,000,000
	Thornapple River:			
10	Sec. 10, T. 35 N., R. 6 W.	*18	*300	.....
11	Sec. 4, T. 36 N., R. 5 W.	*18	*400	.....
12	Sec. 20, T. 38 N., R. 4 W.	*12	*250	.....
13	Sec. 4, T. 39 N., R. 4 W.	*15	*250	.....
14	Brunnett River, sec. 17, T. 38 N., R. 5 W.	*15	*325	.....
15	Torch River, sec. 16, T. 42 N., R. 4 W.	*20	*300	.....

[1] Authority: Nos. 1-4 and 6-9, United States engineers; 5 and 10-15, Chippewa Lumber and Boom Company.

[2] Dimensions marked with an asterisk (*) were estimated by the owner, The Chippewa Lumber and Boom Company.

[3] From report of Chief Engineer, U. S. Army.

TRIBUTARIES OF CHIPPEWA RIVER.

Flambeau River.

DRAINAGE AND WATER POWERS.

In size of drainage area, Flambeau River ranks first among the tributaries of the Chippewa. Indeed, because of its central location in the drainage basin, it might properly be regarded as the prolongation of the main stream itself. Regardless of its size, however, its water power must, in large part, continue for some time unused, because of its forested location and its lack of railroad facilities. The settling of this area will soon justify the extension of present railroads and the building of new ones. Flambeau River is crossed at Ladysmith by the Minneapolis, St. Paul and Sault Ste. Marie Railway, near its center (at Park Falls) by the Wisconsin Central Railway, and at its upper headwaters by the Chicago and Northwestern Railway.

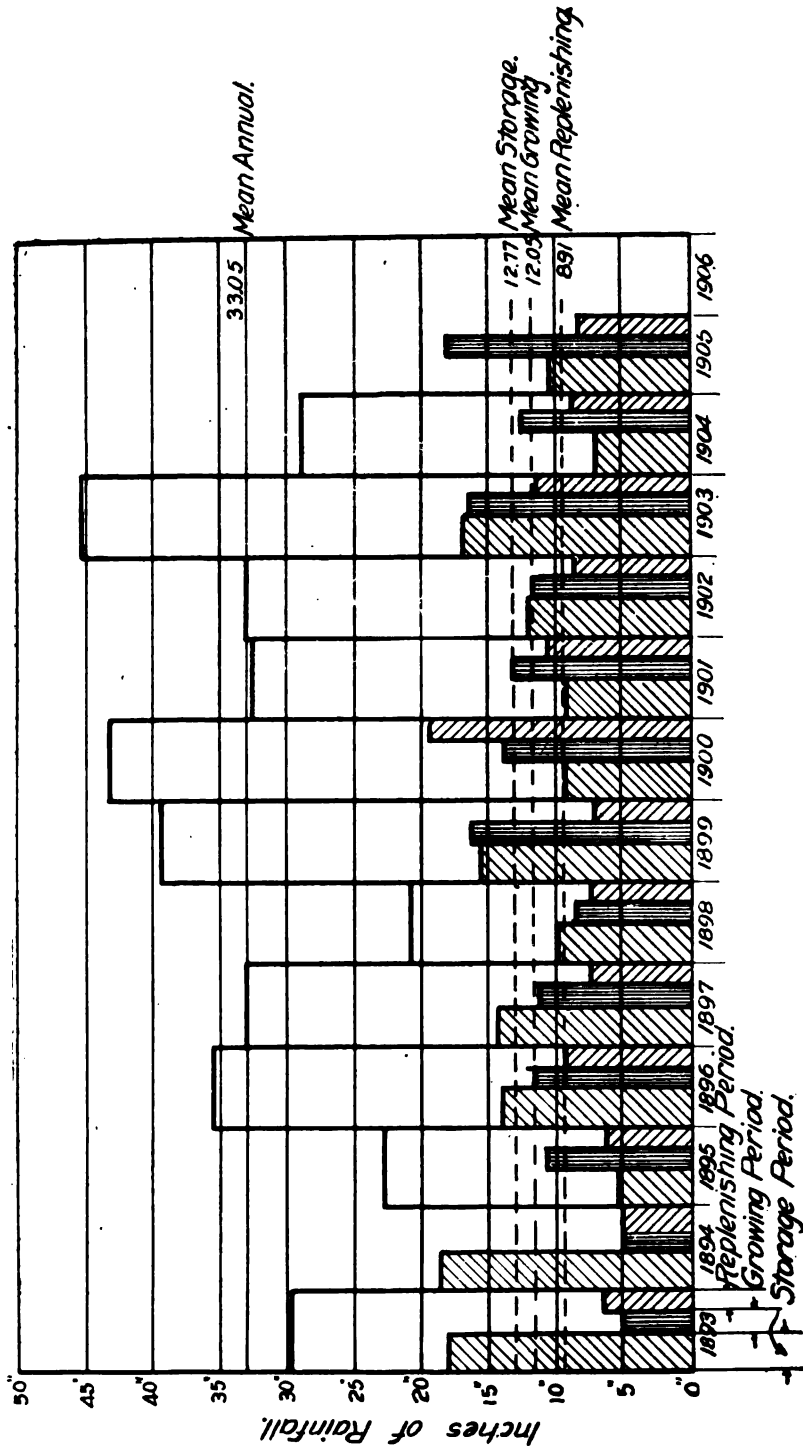


Fig. 13.—Rainfall on the watershed of Flambeau River above Ladysmith, Wis. Watershed 2120 square miles.

During the past year, the Wisconsin Central Railroad has completed its Superior branch from a point near the Black River crossing on its main line, and already the portion between this terminus and Ladysmith is in operation. The Chicago, St. Paul, Minneapolis and Omaha Railway has also extended its branch eastward from Coudary, crossing the Chippewa River and paralleling the Flambeau for twenty miles west of Park Falls.

Between Park Falls and Ladysmith is a reach of 50 miles unserved by railroad, and yet with no point at a greater distance than 15 miles from the present railroads. It is significant that the two points with transportation facilities, Ladysmith and Park Falls, have established large paper and pulp mills and other manufactories. The unusually steady flow, the soft water and the proximity of almost unlimited quantities of pulp wood should make this river a center of the paper and pulp industry. Transportation alone is lacking.

Flambeau River has its source in the largest number of lakes and connecting swamps with the greatest aggregate storage capacity of any river in the state. This storage capacity has been increased in many cases by lumbering dams built at the lake outlets, but as yet many opportunities for the storing of surplus water remain unimproved. These lakes lie in the highest portion of the state, at elevations varying from 1,560 to 1,650 feet or more above the sea.

In order to point out the power possibilities along the Flambeau river a survey was made during 1906 from its mouth to a point 120 miles above. From the data collected, sheets have been prepared showing a profile of the water surface, a plan of the river, contours along the bank, and prominent natural or artificial features. The results of this survey have been published on separate sheets and may be had on application to the Director of the Geological Survey.

The levels taken show that the total fall in the 95 miles below Park Falls is 419 feet, or 4.4 feet per mile. In the 63 miles between Boulder Lake and Park Falls, the river has a fall of 156 feet, or only 2.5 feet per mile.

Following is a profile of the river together with a detailed description of the falls and rapids along the 114 miles covered by the cooperative state and federal survey.

Profile of Flambeau River from mouth to Boulder Lake.

No.	Station.	Distance. From mouth.	Distance. Between points.	Elevation above sea level.	Descent between points. Total.	Descent between points. Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	0.0	.....	1,050.0	.....	.....
2	SW. ¼ sec. 34, T. 34 N., R. 7 W.	7.0	7.0	1,064.0	14.0	2.0
3	Ducomon rapids, NW. ¼ sec. 23, T. 34 N., R. 7 W.	9.35	2.25	1,070.0	6.0	2.7
4	New dam, foot of rapids	13.5	4.25	1,081.0	11.0	2.6
5	SW. ¼ sec. 9, T. 34 N., R. 6 W.	16.9	3.4	1,088.4	7.4	2.2
6	Ladysmith, below dam	20.4	3.5	1,099.0	10.6	3.0
7	Ladysmith, above dam	20.4	0.0	1,115.3	16.3	.....
8	Backwater Ladysmith dam	25.4	5.0	1,117.0	1.7	0.3
9	Yellow Banks Rapids foot of	27.1	1.7	1,128.0	11.0	6.4
10	Little Falls Rapids	28.6	1.5	1,137.0	9.0	6.0
11	West line of Sec. 9 T, 35 N, R., 5 W	30.4	1.8	1,152.0	15.0	8.3
12	SE. corner Sec. 10, T. 35, N. R., 5 W	32.7	2.3	1,163.0	11.0	4.8
13	North line Sec. 11, T. 35, N. R., 5 W	33.9	1.2	1,173.0	10.0	8.3
14	Foot Big Falls, S. line Sec. 35, T. 36, N. R., 5 W.	35.0	1.1	1,177.8	4.8	4.4
15	Head of Big Falls	36.1	1.1	1,209.0	32.2	2.9
16	N. line S. 25, T. 36, N. R., 5 W	37.4	1.3	1,217.0	8.0	6.0
17	N. line S. 19, T. 36, N. R., 4 W. Rock Isl. Rapids	39.6	2.2	1,233.0	16.0	7.3
18	Head of Little Cedar Rapids	41.4	1.8	1,247.0	14.0	7.7
19	4th Pitch Cedar Rapids; foot of	42.7	1.3	1,254.0	7.0	5.4
20	3rd Pitch Cedar Rapids; foot of	43.7	1.0	1,263.0	9.0	9.0
21	2nd Pitch Cedar Rapids; foot of	44.45	.75	1,268.0	5.0	7.0
22	1st Pitch Cedar Rapids; head of	45.70	1.25	1,279.0	11.0	9.0
23	Forks of Flambeau	48.9	3.2	1,284.0	5.0	1.6
24	Flambeau Falls—head of	50.4	1.5	1,298.0	14.0	9.3
25	Porcupine Rapids foot of	54.0	3.6	1,311.0	13.0	3.5
26	Town line, towns 37 and 38 N.	56.5	2.5	1,326.0	15.0	6.0
27	N. line Sec. 16, T. 38, R. 3 W.	62.0	5.5	1,336.0	10.0	1.9
28	N line Sec. 3, T. 38, R. 3 W.	65.75	3.75	1,355.0	19.0	5.0
29	N line Sec. 27, T. 38, R. 3 W.	68.3	2.55	1,369.0	14.0	5.6
30	SE. ¼, SE. ¼, Sec. 1, T. 38, R. 3 W	72.3	4.0	1,377.0	8.0	2.0
31	Barnabee Rapids, foot, S. line S. 17, T. 39, R. 2, W.	78.05	5.75	1,383.0	6.0	1.0
32	S. line Sec. 15, T. 9, R. 2 W.	81.3	3.25	1,400.0	17.0	5.2
33	S. line Sec. 7, T. 39, R. 1 W.	86.6	5.3	1,419.0	19.0	3.6
34	Town line—bet T. 39 and 40	91.1	4.5	1,436.5	17.5	4.9
35	Lower dam—Park Falls, foot of	95.6	4.5	1,448.5	12.0	2.7
36	Lower Dam Park Falls, crest	95.6	.....	1,469.0	20.5	.....
37	Wisconsin Central Ry. Bridge, Park Falls	97.0	1.40	1,469.9	0.9	0.7
38	Below tail-race upper dam Park Falls	97.2	0.2	1,471.8	1.9	9.5
39	Upper Dam, Park Falls, crest of	97.4	0.2	1,486.0	14.2	28.0
40	Rapids, foot of, Sec. NW. ¼, S. 38, T. 41, R. 1 E.	103.1	5.7	1,488.0	2.0	0.3
41	Rapids, head of, N line S. 28, R. 1 E	105.4	2.3	1,506.5	18.5	8.0
42	East line Sec. 6, T. 41, N. R., 2 E.	111.9	6.5	1,520.0	13.5	2.0
43	Rapids, head of, town line, towns 41-42	114.5	2.6	1,546.0	26.0	10.0
44	Manitowish River, junction of Bear Creek	129.5	15.0	1,568.0	22.0	1.5

Profile of Flambeau River from mouth to Boulder Lake—Continued.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
45	Rest Lake, mouth of, sec. 8, T. 42, N. R., 5 E.	141.5	12.0	1,587.0	19.0	1.6
46	Island Lake, inlet of	149.5	7.50	1,592.0	5.0	.6
47	Boulder Lake	158.5	9.5	1,625.0	33.0	3.5

Authority:
Numbers 1-43 inclusive, U. S. G. S. and State Cooperative Survey.
Numbers 44-47 inclusive, U. S. Engineer, U. S. Army, datum uncertain.

DAM SITES ON THE FLAMBEAU RIVER.

In the stretch of 20 miles between Ladysmith dam and the mouth of the Flambeau, the river has a fall of only 49 feet, and, as will be seen from the profile, with only a single concentration of fall.

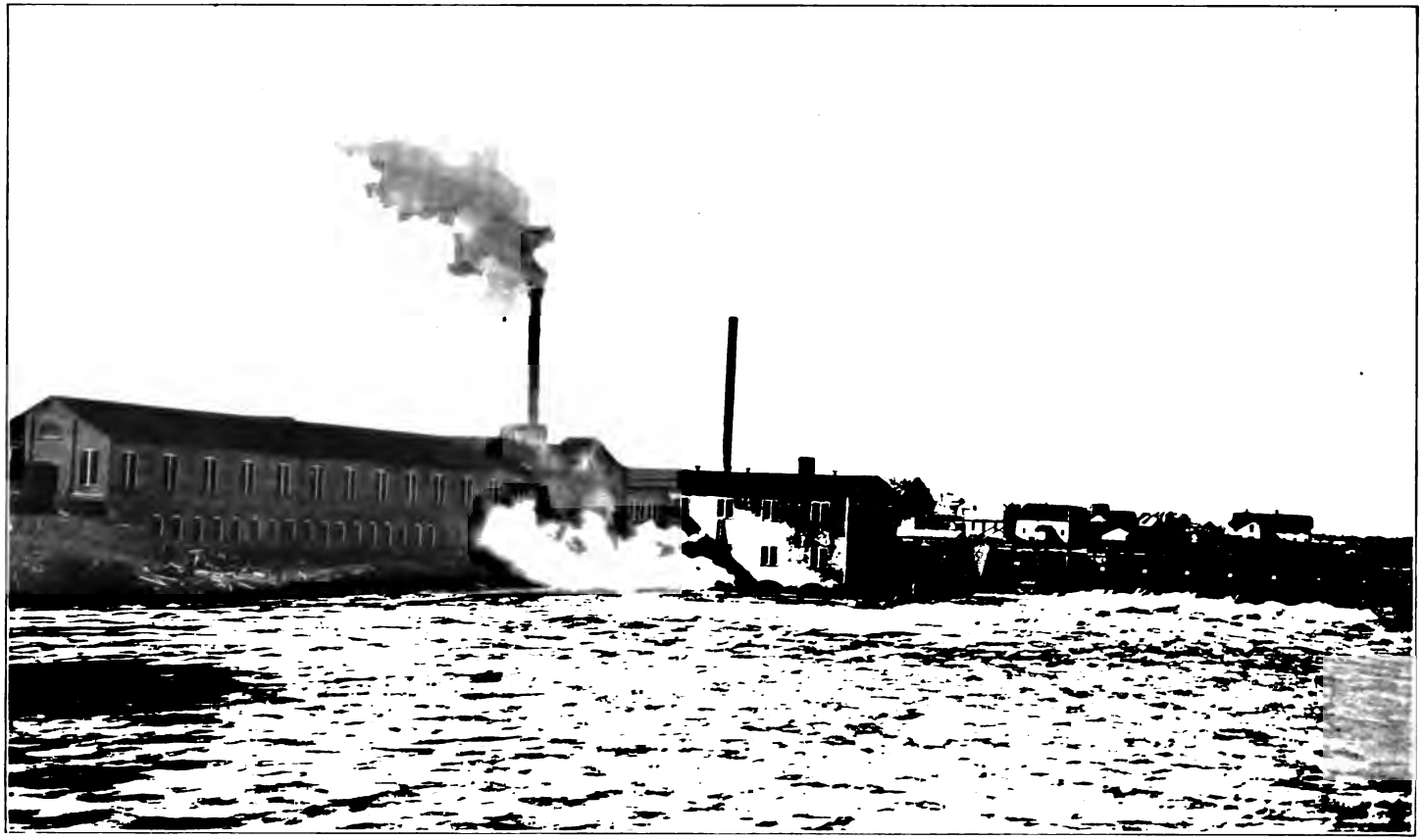
During the past year, a concrete dam, 225 feet long, has been erected in Section eighteen, Township thirty-four north, Range six west, which develops a head of 18 feet. This dam was constructed by the Menasha Paper Co. This company has installed seven turbines, rated at 3,000 horsepower, all used in the manufacture of ground wood pulp. No steam power is used.

About three-quarters of a mile above the mouth of Flambeau River, the banks are high enough to allow of a 15 foot dam.

From the foot of Big Falls to the foot of the Ladysmith dam, a distance of 15 miles, the river has a total fall of 79 feet, only 16 feet of which have been developed. For nearly the entire distance, the river flows between high banks which will allow of two 25 foot dams. In this stretch, the river has a width of about 400 feet, the bed of the river, and the banks in part, being in the pre-Cambrian rocks.

Ladysmith Dam.—This is a timber structure, about 350 feet long, which develops a head of 16 feet. The owners of this dam, the Menasha Wooden Ware Company, have installed six 45-inch and one 35-inch turbines. The power is used to run a paper and pulp mill and also for the manufacture of wooden ware. A view of the dam and paper mill is shown in Plate XXXVIII.

Ladysmith is a town of about 300 inhabitants. Until recently, the town had only one railroad, the Minneapolis, St. Paul and Sault Ste. Marie, but during 1906 the Wisconsin Central Railroad built



DAM AND PAPER MILL AT LADYSMITH, WISCONSIN.
Flambeau River, head 16 feet.

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Fig. 1. BLACK RIVER AT LOW WATER. NEILLSVILLE.
(in PreCambrian rocks)

Fig. 2. LOWER PITCH OF BIG FALLS, FLAMBEAU RIVER.

its Ashland branch through the town from a point on the main St. Paul division near its Black River crossing. This insures good transportation facilities.

Little Falls Power.—A dam could be located in the northeast quarter of section thirty, township thirty-five, range five west, a few feet above the back water of the Ladysmith dam, which would develop a head of about 25 feet. This would require a levee about 1,000 feet long in the right bank. Such a dam would back up the water over the Yellow Banks Rapids and also Little Falls, but would not submerge much land. It is estimated that about 4,000 horsepower for 24 hours per day would be developed for nine months per year.

Burnt Island Rapids.—These rapids are located principally in Section eleven, Township thirty-five, Range four west, but there is swift water for two miles below. The banks are sufficiently high in the southeast quarter, Section eight, Township thirty-five, Range five west, to allow a dam to be here constructed with a head of 25 feet. This would include the Burnt Island Rapids and back the water nearly to the foot of Big Falls. Between the foot of Big Falls and the forks of the Flambeau, a distance of 14.5 miles, the river has a fall of 106 feet, or 7.3 feet per mile.

Big Falls Rapids.—These rapids include by far the most important concentration of fall on the river. They are located principally in Section thirty-five, Township thirty-six, Range five west, and extend from the south line of above section to a short distance above its northern boundary. In this stretch the river flows between high rock banks and with but little over half its normal width. A head of about 55 feet could be secured by a 20 foot dam at the head of Big Falls in connection with a long canal. This would back up the water to about the north line of Section nineteen, Township thirty-six north, Range four west. A branch logging road from the St. Paul, Minneapolis and Sault Ste. Marie Railroad extends to a point near this dam site. A view of the lower pitch of this rapids is shown in Plate XXXIV.

Little Cedar Rapids.—A 20-foot dam near the west line of Section eighteen, Township thirty-six north, Range four west would back up the water to a point near the foot of the fourth pitch of Cedar Rapids in the southeast quarter of section five.

Cedar Rapids.—These rapids comprise four pitches about a mile apart and aggregating twenty-five feet in all. This head could be

developed by a dam located near the line between sections five and eight. In the three miles between the upper pitch of Cedar Rapids and the Forks of the Flambeau, the river has a fall of only four feet.

Forks of the Flambeau.—Near the center of Section thirty-one Township thirty-seven, Range three east, are located the Forks of the Flambeau. Above this point, the two river valleys are decidedly smaller and strangely divergent in course. About 1,000 feet below the forks, the banks are sufficiently high to develop a head of at least 20 feet. Such a dam would back the water in Dore Flambeau to the southeast corner of section thirty-three, a distance of about four miles, and in Flambeau River the same distance, covering Flambeau Rapids and all three pitches of Wannigan Rapids. The drainage area of this dam site is 1,760 square miles, or little less than at Ladysmith.

Between the forks of the Flambeau and the Wisconsin Central Railway bridge at Park Falls, a distance of 47 miles, the river has a fall of 186 feet, or 4 feet per mile. The total fall in the lower half of this stretch is the same as in the upper half, but the lower half has more concentrations.

Porcupine Rapids.—Between the north line of Section thirteen, Township thirty-seven, Range four west, a distance of nine miles, the river falls only 24 feet, but nearly 20 feet of this could be developed by a dam located near the north line of section thirteen. Porcupine Rapids include a fall of five feet in a distance of 1,000 feet and are located in the southwest quarter of Section seven, Township thirty-eight north, Range three west. This power would have a relatively large pondage.

Sec. 9, T. 38 N., R. 3 W.—In the southwest quarter of this section, a head of between 15 and 20 feet could be developed. Fifteen feet head would develop all the remaining fall in township thirty-eight. In the next 12.5 miles above the town line between towns thirty-eight and thirty-nine, the river makes a big bend of 360 degrees, the entire distance being devoid of quick water.

Barnabee Rapids.—These are located in Sections sixteen and seventeen, Township thirty-nine, Range three west, but quick water extends up the river for two miles or more. A head of 15 to 20 feet could be easily developed by a dam near the foot of Barnabee Rapids.

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LOWER PAPER MILL DAM AT PARK FALLS, WISCONSIN.
Flambeau River, 16 feet head.

The remaining 40 feet of fall below the lower dam at Park Falls could be developed in one or two dams at several points, as the banks are frequently high on both sides.

Park Falls Powers.—The drainage area of Flambeau River above Park Falls is 760 square miles, but this includes the lake region with its numerous storage reservoirs. The latter give an unusually steady flow to the river, an effect which could be greatly increased by the building of more and higher dams at the outlet of the lakes.

In a state of nature, the river has a fall of about 34 feet, between a point one-half mile above the Wisconsin Central bridge and a point 1.5 miles below it. This fall has been improved by two dams at the extreme ends of the above stretch of river, both belonging to the Flambeau Paper Company.

The lower dam is a rock filled timber dam which develops a head of 16 feet. The company have installed turbines rated at 1,100 horsepower. This dam could increase its head to 25 feet by relocating the dam about a mile below its present site, thereby improving what are known as Potato Rapids. The present dam backs the water to the railroad bridge. A view of this dam is shown in Plate XXXIX.

The upper dam is an old timber dam, at present in a very poor state of repair. This dam has at present an average head of 16 feet. The Flambeau Paper Company have a modern plant and have installed 13 turbines rated at 1,300 horsepower.

This dam site is an excellent one, and as the banks are high on both sides, could have its present head increased from 25 to 30 feet without much flooding. At the present time, this dam backs the water to the northwest quarter of Section thirty-three, Township forty-one north, Range one east, a distance of 5.5 miles.

Between the mouth of Turtle River and the back water of the upper dam, a distance of 11.5 miles, the river has a fall of 60 feet, largely concentrated in two places, viz.:

Schultz Rapids.—These rapids are located in Sections thirty-three and twenty-eight, Township forty-one north, Range one east. They consist of two pitches separated by about a quarter of a mile of slow water. The upper pitch of seven feet is located in section twenty-eight, while the lower pitch of 10 feet is located in section thirty-three. In the northwest quarter of section thirty-three, the banks

are high enough to develop a head of at least 30 feet. Such a dam would back the water to the east line of Section six, Township forty-one north, Range two east.

Island Rapids.—These rapids include a fall of about 22 feet, mostly located in Section four, Township forty-one north, Range two east. A good site for a dam is near the east and west quarter line in Section five, Township forty-one north, Range two east. A 25 foot dam would develop all the fall to the mouth of the Turtle River. This is as far as the present survey of Flambeau River extended. From levels taken by the United States Engineers, 25 years ago, the fall in the 35 miles above the mouth of the Turtle River is seen to be only 51 feet, or 1.4 feet per mile.

Rainfall and Run-off.—Like all the northern rivers of the state the minimum flow of Flambeau River occurs in severe midwinter weather or during very dry summers in the months of July and August. At the present there are not sufficient discharge data covering periods when the river is frozen to construct an accurate rating curve for such periods. Because of the extensive forests and the numerous lakes and swamps, an ordinary flow of 0.8 second-foot per square mile of drainage area would seem conservative. By the proper regulation of present dams at the headwaters it is likely that this discharge could be considerably increased.

In February, 1903, the United States Geological Survey established an observing station at the Ladysmith dam, and has taken daily gage readings since. Discharge measurements are taken by current meters and are being continued so that in time an accurate estimate of the river's discharge will be available. The following tables give such daily observations: discharge measurements and computations as have become available since the establishment of the station, and also a record of rainfall for the corresponding period:

In 1906 a dam was built a few miles below Ladysmith which backs water at certain times on the gage. The Ladysmith station has accordingly been abandoned.

Discharge measurements of Flambeau River near Ladysmith, Wis., for 1903, 1904, 1905 and 1906.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	Square feet.	Feet per second.	Feet.	Second-feet.
1903.						
February 13[1]	L. R. Stockman	325	472	1.64	16.20	773
March 19[2]	do	366	1,871	1.77	18.95	3,312
April 8	do	349	1,330	2.80	17.40	3,727
May 6	do	361	1,927	3.70	18.97	7,113
June 16	do	342	703	1.91	16.00	1,345
July 11	do	342	1,430	2.95	18.10	4,222
August 21	do	342	995	2.69	16.85	2,681
September 10	E. C. Murphy	364	1,579	3.36	18.05	5,303
October 23	L. R. Stockman	348	1,271	3.07	17.21	3,899
1904.						
May 16	E. Johnson, jr	350	1,333	3.15	17.88	4,203
June 3	do	350	1,448	2.99	17.45	4,321
August 29	do	349	733	2.07	16.06	1,517
September 20	do	343	702	2.21	16.01	1,554
October 12	F. W. Hanna	364	1,658	3.37	18.58	5,589
1905.						
April 8	S. K. Clapp	129	1,537	3.49	18.27	5,367
May 23	do	357	1,292	2.69	17.60	3,474
June 14	M. S. Brennan	354	1,232	2.67	17.35	3,288
July 12	do	353	1,015	2.54	16.80	2,576
August 12	do	345	623	1.84	15.66	1,144
September 23	F. W. Hanna	353	1,404	3.02	17.75	4,236
1906.						
January 26	M. S. Brennan	.....	344	501	16.13	[3]639
April 16	Horton and Brennan	.....	330	2,630	20.74	10,800

[1] Frozen.
[2] Log jam below.
[3] Entirely frozen over. Gage height to bottom of ice, 15.33 feet; thickness of ice varied from 0.8 to 0.5 foot below ice surface. The discharge was about 40 per cent of the open-channel rating at gage height 16.13 feet.

Mean daily gage height, in feet of Flambeau River near Ladysmith, Wis., February 15, 1903, to December 31, 1906.

Day.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.											
1	.....	16.15	17.00	18.30	19.80	15.65	.....	17.00	17.20	16.00	15.90
2	.....	16.60	16.80	18.40	19.65	16.15	.....	16.70	17.30	16.25	15.75
3	.....	16.50	16.90	18.60	18.95	17.25	.....	16.80	17.60	15.85	15.95
4	.....	16.10	16.90	19.05	18.60	18.10	.....	16.30	19.65	15.85	15.60
5	.....	16.30	17.05	19.10	18.10	18.90	.....	16.80	19.70	15.85	15.80
6	.....	16.50	16.40	19.10	17.55	19.05	.....	16.90	19.35	15.85	15.80
7	.....	16.60	16.90	19.10	17.55	19.20	.....	16.90	19.25	15.90	16.95
8	.....	16.10	17.45	18.80	17.30	18.85	.....	17.30	19.25	15.65	15.80
9	.....	16.50	17.35	18.70	16.95	18.70	.....	18.20	19.30	15.70	14.70
10	.....	16.50	17.25	17.95	16.60	18.60	18.20	18.20	19.35	15.85	16.50
11	.....	16.05	17.26	18.25	16.75	18.75	18.00	18.00	18.95	16.00	16.35
12	.....	16.45	17.30	18.80	16.80	18.55	17.90	18.40	18.65	15.85	16.30
13	.....	16.35	17.25	19.55	16.30	18.30	17.80	19.00	18.45	15.85	16.50
14	.....	16.35	17.50	19.80	16.15	17.85	17.70	19.80	18.25	15.80	16.45
15	16.00	16.60	17.40	19.65	16.35	17.70	17.50	20.40	17.90	16.80	16.55
16	16.10	16.15	17.20	19.55	16.50	17.65	17.30	20.50	17.85	15.75	16.35
17	16.05	16.20	16.95	19.40	16.05	17.60	17.30	20.50	17.80	15.80	16.40
18	16.00	16.30	17.00	19.45	16.05	17.35	17.20	20.30	17.50	15.00	16.70
19	15.90	18.25	16.90	19.05	15.85	17.35	17.00	20.00	17.35	15.50	16.60
20	16.00	20.35	16.85	19.20	15.80	17.20	17.00	19.70	17.25	15.50	16.67
21	15.90	19.30	16.90	19.25	15.85	17.15	17.10	19.30	17.25	15.45	16.67
22	16.05	18.50	16.65	18.85	15.95	16.70	16.90	18.90	17.15	15.25	16.67
23	16.00	18.45	16.65	19.15	15.65	16.70	16.70	18.50	17.05	15.40	16.66
24	16.25	17.30	17.30	18.90	15.90	16.70	16.80	18.20	17.00	15.65	17.00
25	16.00	17.60	17.30	19.00	15.60	16.90	17.10	18.00	16.80	15.45	16.69
26	15.95	17.25	17.25	19.55	15.85	(1)	16.80	17.70	17.00	15.55	16.66
27	16.40	17.00	17.15	20.60	15.60	(1)	17.00	17.85	16.80	15.85	16.50
28	16.25	17.10	17.20	21.45	15.70	(1)	16.90	17.50	16.56	15.80	16.10
29	.....	17.00	17.40	21.45	15.95	(1)	16.80	17.30	16.65	15.80	16.80
30	.....	16.75	18.45	21.20	15.80	(1)	16.70	17.20	16.05	15.85	16.80
31	.....	16.60	.....	21.45	.....	(1)	16.80	.....	16.20	.....	16.70

[1] Chain gage stolen.

Mean daily gage height, in feet, of Flambeau River near Ladysmith, Wis., February 15, 1903, to December 31, 1906—Continued.

Day.	Jan.[2]	Feb.[3]	Mar.[2]	Apr.[3]	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	16.75	16.75	17.00	16.90	18.70	17.50	17.58	15.15	16.25	(5)	17.25	15.65
2	16.95	16.75	17.05	17.20	18.55	17.40	17.77	15.40	16.30	(5)	17.30	15.05
3	16.75	16.10	17.00	16.80	18.60	17.42	17.70	(6)	16.38	(5)	17.20	15.95
4	16.85	16.80	17.05	16.90	18.35	17.43	19.90	(6)	17.78	(5)	16.90	14.50
5	17.00	16.90	17.15	16.85	18.45	18.00	18.82	15.60	17.65	16.05	16.70	15.15
6	16.50	16.70	16.95	16.80	18.60	18.02	18.88	15.72	17.20	16.05	16.80	15.30
7	16.50	16.80	16.90	17.10	18.60	18.25	18.75	15.13	17.28	16.10	16.30	14.87
8	16.65	16.75	17.15	17.25	18.85	18.27	18.75	15.40	17.30	16.10	16.20	15.78
9	16.65	16.75	16.90	17.05	19.20	17.90	18.05	15.75	17.03	17.05	16.17	15.57
10	16.70	16.65	17.50	17.00	19.15	17.22	17.95	15.92	16.00	18.70	16.15	15.55
11	16.60	16.70	17.40	17.10	18.90	17.10	17.70	15.85	16.40	18.65	16.05	15.25
12	16.55	16.95	17.05	17.10	18.80	17.25	17.25	16.00	16.32	18.60	15.55	15.77
13	16.50	17.00	17.30	17.15	18.35	17.15	16.40	15.90	16.45	18.50	15.60	15.55
14	16.70	16.70	17.20	17.05	18.15	17.12	16.30	15.90	16.30	18.43	15.45	15.30
15	16.70	16.90	17.20	17.25	18.01	16.60	16.12	15.85	16.15	18.30	15.82	15.35
16	16.75	16.95	17.00	17.20	17.95	16.55	16.15	16.02	16.05	17.85	15.28	15.45
17	16.60	16.55	17.15	17.10	18.01	16.35	16.03	15.90	16.05	17.20	15.55	15.35
18	16.60	17.10	17.20	17.05	18.01	16.25	16.00	15.85	16.13	16.95	15.72	15.30
19	16.65	16.95	17.15	17.00	18.08	16.32	15.60	15.95	16.15	17.15	15.70	15.50
20	16.30	16.95	17.05	16.85	17.05	15.95	15.80	16.75	16.00	17.25	15.60	15.57
21	16.75	17.55	17.05	16.85	17.03	15.88	15.95	16.00	16.00	17.60	15.45	15.70
22	16.75	16.90	17.16	16.65	17.01	16.15	15.85	16.20	15.90	17.80	15.82	15.72
23	16.75	17.00	16.85	17.20	17.04	15.95	15.80	16.35	15.95	17.75	15.27	15.68
24	16.65	16.60	17.15	17.20	17.06	16.35	15.70	16.45	15.95	17.75	15.55	15.00
25	16.70	17.00	16.95	18.00	18.40	16.55	15.85	16.65	16.40	17.85	15.72	15.65
26	16.70	16.90	16.95	18.40	19.00	16.70	16.15	16.45	16.40	17.75	15.70	15.70
27	16.45	17.00	16.95	18.45	19.40	16.95	16.76	16.45	16.40	17.65	15.55	16.10
28	16.65	16.95	17.15	18.50	19.30	17.05	16.75	16.20	16.45	17.55	15.40	15.75
29	16.60	16.95	17.05	18.50	18.80	17.05	15.70	16.10	16.40	17.65	14.95	15.80
30	16.75	.....	16.45	18.90	18.40	17.20	15.25	16.27	16.45	17.70	15.55	16.30
31	16.65	.....	17.20	.....	17.80	.....	15.55	16.15	.....	17.22	.....	16.40

[2] Frozen from January 1 to March 30, when ice begins to break. Ice varied from 6 to 18 inches in thickness.
[3] Ice conditions March 31 to about April 10.
[4] Ice conditions during December.
[5] Weight gone.
[6] Key lost; no gage height taken on August 3 and 4.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	(1)	.....	.....	18.80	16.8	17.40	17.70	15.80	16.90	16.55	16.40	16.15
2	.....	.....	.....	18.40	16.8	16.25	17.60	15.90	16.60	16.55	16.25	15.90
3	.....	.....	.....	19.00	16.8	16.40	17.50	15.80	16.90	16.35	16.15	15.85
4	.....	16.4	16.80	19.20	17.0	16.80	17.60	15.70	17.00	16.25	[illegible]	16.20
5	.....	.....	.....	18.90	17.3	17.80	18.60	15.75	17.00	16.20	16.20	15.95
6	.....	.....	.....	18.40	17.6	18.70	19.00	15.35	16.90	16.15	16.15	16.10
7	16.3	.....	.....	18.40	17.6	19.60	19.20	15.35	16.60	15.80	16.20	16.45
8	.....	.....	.....	18.20	17.4	19.30	18.80	15.30	16.70	15.95	16.15	16.15
9	.....	.....	.....	18.10	17.1	18.30	18.50	15.50	16.50	15.80	16.05	16.25
10	.....	.....	.....	17.80	17.4	18.70	18.20	15.30	16.40	15.95	15.85	16.25
11	.....	16.5	16.00	17.40	17.5	18.60	17.40	15.40	16.20	15.55	16.05	15.90
12	.....	.....	.....	17.20	17.8	18.60	17.00	15.55	16.20	16.20	16.30	15.80
13	.....	.....	.....	17.20	17.8	17.60	17.00	15.40	16.25	16.15	16.30	15.90
14	16.6	.....	.....	18.20	18.0	17.50	17.00	15.32	16.25	16.10	16.20	15.70
15	.....	.....	.....	18.10	18.3	17.60	16.70	15.45	16.45	16.40	16.10	15.70
16	.....	.....	.....	17.60	18.2	17.70	16.60	15.60	16.80	16.75	16.25	16.20
17	.....	.....	.....	17.20	18.4	18.00	16.35	15.55	17.10	16.75	16.05	16.40
18	.....	16.7	16.90	16.55	18.6	19.70	16.35	15.90	17.05	17.00	15.90	15.70
19	.....	.....	.....	16.55	18.6	19.60	16.40	16.80	17.70	17.65	15.90	15.95
20	.....	.....	.....	16.45	18.4	19.40	16.15	16.90	17.80	17.20	15.85	15.45
21	16.7	.....	.....	16.55	18.0	19.10	16.10	17.10	[illegible]	17.65	15.90	15.65
22	.....	.....	.....	17.00	18.0	18.90	16.20	16.90	18.40	17.85	15.70	15.60
23	.....	.....	.....	16.30	17.4	18.60	15.90	16.60	17.80	17.45	15.75	15.65
24	.....	.....	16.80	16.35	18.0	18.40	15.50	16.45	17.60	17.30	15.60	15.70
25	.....	16.6	16.45	16.15	17.6	18.00	15.90	16.80	17.30	17.10	16.00	16.75
26	.....	.....	16.35	16.05	17.4	18.00	15.75	16.35	17.20	16.85	16.60	16.10
27	.....	.....	16.25	17.40	17.2	18.00	15.80	16.25	16.80	16.85	16.10	15.60
28	16.6	.....	17.10	17.40	18.0	17.70	15.80	16.80	16.80	16.80	16.60	16.00
29	.....	.....	17.90	17.00	17.8	17.70	15.75	17.00	16.70	16.70	16.15	15.90
30	.....	.....	18.20	16.80	17.6	17.70	15.70	17.20	16.20	16.65	15.90	16.15
31	.....	.....	18.00	.....	17.4	.....	15.55	17.00	.....	16.30	.....	16.10

[1] River frozen entirely across January 1 to March 23. March 11-23 there was water on the ice. Gage heigths are to water surface in a hole in the ice. The following comparative readings were also made:

Daily gage height, in feet, of Flambeau River near Ladysmith, Wis., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1906.												
1	16.72	.....	.....	16.92	17.82	17.35	16.80	15.20	16.15	16.15	20.25	19.55
2	16.90	.....	.....	16.92	18.05	17.30	16.92	15.75	16.25	15.70	20.25	19.00
3	16.85	.....	.....	17.00	17.65	17.15	17.10	16.20	16.12	15.80	20.30	.....
4	17.35	16.80	17.10	17.85	18.30	16.90	16.80	15.25	16.10	15.40	20.50	.....
5	16.65	.....	.....	18.15	18.60	16.82	16.82	15.70	16.05	16.00	20.10	.....
6	17.10	.....	.....	18.20	18.55	17.16	16.20	17.15	16.10	15.20	20.55	.....
7	.....	.....	.....	18.05	18.20	17.78	16.35	17.30	16.35	15.80	20.05	.....
8	.....	.....	.....	17.45	17.78	16.25	16.10	16.85	15.50	14.90	19.55	.....
9	.....	.....	.....	18.15	17.52	17.90	16.35	16.30	15.55	15.75	19.40	.....
10	.....	.....	.....	18.38	17.40	18.20	16.38	16.20	15.70	15.85	19.90	.....
11	.....	17.10	15.60	18.30	17.18	17.72	16.40	16.35	15.60	15.72	19.85	.....
12	.....	.....	.....	19.05	17.10	17.45	16.52	16.20	15.65	15.70	17.05	.....
13	.....	.....	.....	19.65	17.10	17.40	16.60	16.15	16.65	15.70	16.45	.....
14	16.70	.....	.....	20.50	17.02	16.85	16.35	16.00	17.12	15.65	16.35	.....
15	.....	.....	.....	20.72	17.25	16.80	16.20	16.00	17.15	15.60	16.50	.....
16	.....	.....	.....	20.65	17.00	16.65	16.40	15.80	17.08	15.75	16.70	.....
17	.....	.....	17.10	20.48	17.50	16.55	16.30	15.90	17.10	15.65	16.75	.....
18	.....	.....	.....	20.35	16.68	16.30	16.20	15.70	17.12	17.05	16.70	.....
19	.....	17.00	.....	20.40	16.68	16.10	16.10	15.35	17.10	[1]18.50	17.00	.....
20	.....	.....	.....	20.40	16.85	16.10	15.95	15.60	16.78	19.75	16.60	.....
21	16.30	.....	.....	20.40	16.65	16.32	16.60	16.45	16.28	19.65	16.30	.....
22	.....	.....	.....	20.10	16.90	16.60	15.88	16.75	17.02	19.70	16.55	.....
23	.....	.....	.....	19.75	16.95	16.50	15.75	16.80	17.08	19.5	18.05	.....
24	.....	.....	.....	19.45	17.32	16.75	15.68	17.00	16.15	19.75	19.30	.....
25	.....	17.4	16.60	19.00	17.32	16.58	16.00	16.65	16.65	20.20	19.35	.....
26	.....	.....	.....	18.70	17.50	16.60	15.55	17.05	16.58	24.40	19.30	.....
27	.....	.....	.....	18.45	17.80	16.62	16.70	16.55	16.25	20.50	19.45	.....
28	19.70	.....	.....	18.05	17.70	16.50	16.65	16.45	16.40	20.45	19.45	.....
29	.....	.....	.....	18.05	17.38	16.82	15.75	16.35	16.20	20.20	19.50	.....
30	.....	.....	.....	17.90	17.80	17.40	15.55	16.20	16.55	20.50	19.55	.....
31	.....	.....	.....	.....	17.50	.....	15.00	16.50	.....	20.40	.....	.....

[1] October 18 a dam below the station was closed, raising the water at the section.

Note.—Rim frozen January 6 to April 4, approximately; also December 3 to 31. During January the average ice thickness was about 1 foot, while during February and March it was 1.6 feet.

Daily gage height, in feet, of Flambeau River near Ladysmith, Wis., for 1906.

Date.	Water surface.	Top of ice.	Thickness.
	Feet.	*Feet.*	*Feet.*
January 7	16.3	16.4	0.7
January 14	16.6	16.8	1.3
January 21	16.7	16.9	1.4
January 28	16.6	16.9	1.5
February 4	16.4	16.9	1.7
February 11	16.5	16.9	1.7
February 11	16.7	17.1	2.0
February 25	16.6	16.9	1.8
March 4	16.8	17.8	1.8

Rating table for Flambeau River near Ladysmith Wis., from March 19, 1903, to December 1, 1903.[1]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-feet.*
15.0	530	16.3	1,765	17.6	4,280	18.8	6,920
15.1	565	16.4	1,925	17.7	4,500	18.9	7,140
15.2	600	16.5	2,085	17.8	4,720	19.0	7,360
15.3	665	16.6	2,245	17.9	4,940	19.2	7,800
15.4	745	16.7	2,405	18.0	5,160	19.4	8,240
15.5	825	16.8	2,575	18.1	5,380	19.6	8,680
15.6	915	16.9	2,755	18.2	5,600	19.8	9,120
15.7	1,010	17.0	2,960	18.3	5,820	20.0	9,560
15.8	1,110	17.1	3,180	18.4	6,040	20.2	10,000
15.9	1,220	17.2	3,400	18.5	6,260	20.4	10,440
16.0	1,340	17.3	3,620	18.6	6,480	20.6	10,880
16.1	1,465	17.4	3,840	18.7	6,700	21.0	11,760
16.2	1,610	17.5	4,060				

[1] Made from measurements between gage heights 16 and 18.95 feet. Curve above and below those points is approximate. To be used only for open river.

Rating table for Flambeau River near Ladysmith, Wis., from January 1. 1904, to December 31, 1904.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-feet.*
15.0	567	16.0	1,399	17.0	2,841	18.4	5,291
15.1	596	16.1	1,542	17.1	2,990	18.6	5,704
15.2	637	16.2	1,686	17.2	3,143	18.8	6,120
15.3	690	16.3	1,830	17.3	3,300	19.0	6,539
15.4	755	16.4	1,974	17.4	3,461	19.2	6,959
15.5	832	16.5	2,118	17.5	3,626	19.4	7,379
15.6	921	16.6	2,262	17.6	3,795	19.6	7,799
15.7	1,022	16.7	2,406	17.8	4,145	19.8	8,219
15.8	1,135	16.8	2,550	18.0	4,511	20.0	8,639
15.9	1,260	16.9	2,695	18.2	4,893		

Rating table for Flambeau River near Ladysmith. Wis., from January 1 to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Second-ft.	Feet.	Second-ft	Feet.	Second-ft.	Feet.	Second-ft.
15.00	600	16.20	1,735	17.40	3,510	18.50	5,770
15.10	670	16.30	1,855	17.50	3,700	18.60	5,980
15.20	745	16.40	1,980	17.60	3,890	18.70	6,190
15.30	825	16.50	2,110	17.70	4,090	18.80	6,400
15.40	910	16.60	2,245	17.80	4,300	18.90	6,610
15.50	1,000	16.70	2,380	17.90	4,510	19.00	6,820
15.60	1,090	16.80	2,530	18.00	4,720	19.20	7,240
15.70	1,185	16.90	2,680	18.10	4,930	19.40	7,660
15.80	1,285	17.00	2,835	18.20	5,140	19.60	8,120
15.90	1,390	17.10	2,995	18.30	5,350	19.80	8,580
16.00	1,500	17.20	3,160	18.40	5,560	20.00	9,000
16.10	1,615	17.30	3,330				

The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903-1905. It is not very well defined.

Rating table for Flambeau River near Ladysmith, Wis., from January 1, 1906, to October 17, 1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Second-ft.	Feet.	Second-ft.	Feet.	Second-ft.	Feet.	Second-ft.
14.90	535	16.20	1,735	17.50	3,700	19.40	7,710
15.00	600	16.30	1,855	17.60	3,890	19.60	8,170
15.10	670	16.40	1,980	17.70	4,090	19.80	8,630
15.20	745	16.50	2,110	17.80	4,300	20.00	9,090
15.30	825	16.60	2,245	17.90	4,510	20.20	9,550
15.40	910	16.70	2,385	18.00	4,720	20.40	10,030
15.50	1,000	16.80	2,530	18.20	5,140	20.60	10,510
15.60	1,090	16.90	2,680	18.40	5,560	20.80	11,000
15.70	1,185	17.00	2,835	18.60	5,980	21.00	11,500
15.80	1,285	17.10	2,995	18.80	6,400	22.00	14,100
15.90	1,390	17.20	3,160	19.00	6,820	23.00	16,800
16.00	1,500	17.30	3,330	19.20	7,260	24.00	19,600
16.10	1,615	17.40	3,510				

Note.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1903-1906. It is well defined between gage heights 15.5 feet and 21 feet. Owing to the closure of a dam below the section the table is not applicable after October 17, 1906.

Estimated monthly discharge of Flambeau River near Ladysmith, Wis. for 1903, 1904, and 1905.

[Drainage area, 6,740 square miles.]

Date.	Discharge.			Run-off.		Rainfall.[1]
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*	*Inches.*
January	.....	.....	.....	.....	.....	0.46
February[2]	.....	.....	860	0.41	0.21	.90
March	10,330	933	2,730	1.29	1.49	2.57
April	6,150	1,925	3,260	1.54	1.72	3.69
May	12,750	5,050	8,187	3.86	4.45	6.04
June	9,120	915	2,749	1.30	1.45	1.64
July[3]	.....	.....	4,598	2.17	2.02	8.70
August[4]	.....	.....	3,431	1.62	1.33	5.66
September	10,660	1,765	5,777	2.72	3.03	8.53
October	8,900	1,400	4,807	2.27	2.62	3.23
November	1,685	530	1,054	.50	.56	.94
December	.....	.....	.....	.....	.....	.87
The year	.....	.....	.....	.....	.....	43.23
1904.						
January	.....	.....	.....	.....	.....	.43
February	.....	.....	.....	.....	.....	1.11
March	.....	.....	.....	.....	.....	1.76
April[5]	6,339	2,334	3,229	1.60	1.78	1.77
May	7,379	2,856	5,183	2.44	2.81	4.64
June	5,034	1,234	2,890	1.36	1.52	5.64
July	8,429	662	2,834	1.34	1.54	2.14
August[6]	2,334	607	1,336	.630	.726	5.01
September	4,109	1,260	2,056	.970	1.08	4.70
October[6]	5,912	1,470	3,517	1.66	1.91	5.61
November	3,300	555	1,416	.668	.745	.19
December[5]	1,974	390	951	.449	.518	2.39
The year	.....	.....	.....	.....	.....	35.43

[1] Rainfall for 1903 is the average of the recorded rainfall at Butternut, Medford and Eau Claire; that for 1904 omits Eau Claire and adds Prentice and Minocqua.
[2] February 15 to 28, inclusive.
[3] July 1 to 25, inclusive.
[4] August 10 to 31, inclusive.
[5] Estimates April and December made as if open channel.
[6] Discharge estimated for August 3 and 4 and October 1 to 4.

Estimated monthly discharge of Flambeau River near Ladysmith, Wis., for 1903, 1904 and 1905—Continued.

[Drainage area, 6,740 square miles.]

Date.	Discharge.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth	
	Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*	*Inches.*
1905.[7]						
March 24-31	.....	5,980	1,795	3,384	1.60	.476
April	.....	7,240	1,558	3,867	1.82	2.08
May	.....	5,980	2,530	4,090	1.93	2.22
June	.....	8,430	1,795	5,223	2.46	2.74
July	.....	7,340	1,000	2.950	1.39	1.63
August	.....	3,160	825	1,069	.787	.907
September	.....	5,560	1,735	2,829	1.34	1.50
October	.....	3,990	1,045	2,305	1.09	1.26
November	.....	2,245	1,090	1,616	.762	.850
December	.....	2,045	955	1,449	.683	.787
1906.[8]						
April (5-30)	.....	10,800	3,600	7,310	3.45	3.34
May	.....	5,980	2,320	3,680	1.74	2.01
June	.....	5,240	1,620	2,900	1.37	1.53
July	.....	3,000	600	1,770	.835	.96
August	.....	3,330	745	1,860	.877	1.01
September	.....	8,080	1,000	2,730	1.29	1.44
October (1-17)	.....	1,340	910	1,170	.552	.35

[7] No estimates for ice period.
[8] Values for 1906 are probably excellent. During the frozen period the discharge probably seldom exceeded 1,500 second-feet and may have declined to a minimum of 500 or less. (See ice measurement.)
[9] The back water of a dam recently constructed below Ladysmith has made it necessary to abandon the station.

TRIBUTARIES OF FLAMBEAU RIVER.

Dore Flambeau River, the south branch of the Flambeau, rises at an elevation of 1,582* feet above the sea, in a group of a dozen lakes, the largest being Long Lake. Its total drainage area is 742 square miles. The river flows in the crystalline rocks much of its length, and in general, it resembles the Flambeau River. Elk River, its largest tributary, joins it 12 miles above the Fork of the Flambeau.

The coöperative survey extended only for a distance of four miles above the mouth of the river, but this included the largest single rapids on the river. Owing to its lakes and swamps, the river has a far more uniform flow than any of the Chippewa tributaries farther south.

* Authority U. S. Army Engineers.

South Fork Falls.—This includes the rapids noted above which are located chiefly in Section thirty-four, Township thirty-seven north, Range three west. The river has rock bed and banks for its entire length in this section. A 15 foot dam located at the head of these rapids near the north line of above section thirty-four would develop a head of 50 feet, or more if conducted by a canal to the foot of the rapids, or a head of 40 feet could be developed by simply a dam at the foot of the rapids. A small water power might be obtained at Carpenter Rapids, the upper pitch of which is on the northeast quarter, and the lower pitch on the southwest quarter of Section 17, Township 37 north, Range 2 west. Rocky Carry Rapids, on Section 9, Township 38 north, Range 1 west, would produce a small power. Near Fifield there is a small water power and on Section 24, Township 40 north, Range 1 east, there is also one.

The lakes at the head of this fork provide fair reservoirs which could be enlarged without great cost.

The following table gives the

Profile of Dore Flambeau River.

No.	Station.	Distance.		Elevation above sea level.	Distance between points.	
		From mouth.	Between points.		Feet.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	.....	.....	1,284	.....	.....
2	Center of Sec. 4, T. 36, N. R 3, W.	2.5	2.5	1,298	14	5.6
3	N. line of Sec. 34, T 37, N. R. 3, W.	4.0	1.5	1,335	37	24.7
4	Fifield, Wis., Cor. Ry. crossing	29	25	1,436	101	4
5	Source, Long Lake	56	27	1,582	146	5.4

Authority. 1-3 inclusive, co-operative survey U. S. G S. and Wis., 4-5 U. S, Engineers' levels datum uncertain.

Dams are maintained by the Chippewa River Improvement Company at the outlet of Long Lake, at Fifield. The same company maintains logging dams at Elk River in Section 11, Township 37 north, Range 2 west, and also in Secion 14, Township 37 north, Range 1 west, with flowage of 1½ and 2½ square miles, respectively. These and other logging dams within this drainage area are listed in the following table:

Logging dams maintained on tributaries of Flambeau River.[1]

No.	Location.	Dam.	
		Height.	Length.
		Feet.	Feet.
	Dore Flambeau River:		
1	Sec. 7, T. 39 N., R. 1 E.; sec. 24, T. 40 N., R. 1 E....	16	350
2	Sec. 16, T. 38 N., R. 1 W.....	.....	.....
3	Secs. 23-26, T. 40 N., R. 3 E.....	15	400
4	Flambeau Lake, sec. 2, T. 40 N., R. 4 E.....	6	24
	Manitowish River:		
5	Sec. 9, T. 42 N., R. 5 E.....	13	400
6	Sec. 24, T. 42 N., R. 6 E.....	17	300
7	Sec. 15, T. 42 N., R. 7 E.....	15	250
	Elk River:		
8	Sec. 11, T. 37 N., R. 2 W.....	10	450
9	Sec. 14, T. 37 N., R. 1 W.....	10	.....
10	Trout River, sec. 14, T. 41 N., R. 6 E.....	4	.....
11	Bear Creek, sec. 2, T. 40 N., R 4 E.....	.....	.....

[1] Authority: Nos. 1 and 3, Wm. Irving, manager, Chippewa Lumber and Boom Co.; 4-8, Flambeau Lumber Co.; 9, J. R. Davis Lumber Co.; 10 and 11, E. S. Shepard. Owners: Nos. 1, 3, and 5-7, Chippewa Lumber and Boom Co.; 2, Lugar Lumber Co.; 8 and 9, Chippewa River Improvement Co.

RED CEDAR RIVER.

Drainage.—An area of 1,957 square miles in the extreme western part of Chippewa Valley is drained by Red Cedar River (sometimes called the Menomonie), which, unlike the other large tributaries of Chippewa River, does not reach the main stream until within a few miles from its mouth. Except at its headwaters, Red Cedar River drains a region underlain by the pre-Cambrian sandstone. As a result, the greater part of the area has a sandy soil. A narrow belt of clayey loam, increasing in width southward, extends along the western limit of this area. The drainage area occupies the U-shaped region included between two terminal moraines, one near the eastern and one near the western border, which unite at the upper headwaters, giving rise to numerous lakes. Five of the largest of these, including Chetac, Long, Red Cedar and Rice have an area of over 20 square miles.

*Geology.**—In its lower course, from a few miles north of Cedar Falls to within a mile of its mouth, the river flows in a rock gorge. In some parts of this stretch, vertical bluffs of sandstone line the river on both sides, giving a minimum width to the valley with frequent small falls and rapids. In this portion the river is still eroding a deeper channel in the soft sandstone.

*Condensed from a paper by Mr. E. B. Hall.

The upper course of the river is in striking contrast to the lower. Here the valley is from one to several miles wide, the river being devoid of rapids. Rock outcrops are also rare and occur on only one side of the stream. The upper river comprises two branches; the eastern and larger one has its source in the Wisconsin drift covered area of Pre-Cambrian rocks of southeastern Washburn and southwestern Sawyer Counties. The western branch heads in the Pre-Cambrian quartzite area of Northern Barron and Western Rusk Counties.

At the present time the upper river is not eroding and at some points is depositing.

There is abundant evidence to show that the lower river is flowing at present in a relatively new channel, the old, filled channel being located a few miles north of Cedar Falls.

Profile.—A study of the profile of Red Cedar River shows that its total descent in the 90 miles above its mouth is 470 feet, or 5.2 feet per mile. This gives opportunity for a large number of water powers. There are about 25 old logging dams on the river, besides about an equal number of sawmills and flouring mills. The following table has been compiled from actual surveys by competent engineers and from checked railroad levels:

Profile of Red Cedar River from its mouth to Red Cedar Lake.[1]

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	0	.....	705.0	.....	.....
2	Dunnville	2.0	2.0	723.4	18.4	9.2
	Downsville dam:					
3	Foot	7.8	5.8	739.0	15.6	2.7
4	Crest	7.8	.0	758.2	19.2	
5	Irving	13.0	5.2	766.4	8.2	3.1
	Menomonie dam:					
6	Foot	16.6	3.6	788.3	21.9	
7	Crest	16.6	.0	803.9	15.6	8.0
8	"Omaha bridge"	18.9	2.3	806.7	2.8	
	Cedar Rapids dam:					
9	Foot	23.4	4.5	823.3	16.6	3.7
10	Crest	23.4	.0	842.0	18.7	5.3
11	Hay River, mouth	30.2	6.8	859.3	17.3	
12	Colfax	35.0	4.8	895.0	35.7	7.4
13	Cameron (2 miles west)	70.0	35.0	1,068.0	173.0	5.0
14	Railroad crossing	74.0	4.0	1,116.0	48.0	12.0
15	Cedar Lake dam, sec. 22, T. 37 N., R. 10 W.	90.0	16.0	1,191.0	75.0	4.7
16	Dam in sec. 25, T. 37 N., R. 10 W.	96.0	6.0	.....	.....	.....

[1] Authority: No. 1, Chicago, Milwaukee and St. Paul Railway; 2-11, O'Keef and Orbison, Appleton Wis., 12, Wisconsin Central Railway; 13, Minneapolis, St. Paul, and Sault Ste. Marie Railway; 14 and 14, Chicago, St. Paul, Minneapolis and Omaha Railway.

A study of this table shows that Red Cedar River has a high gradient, averaging 5.5 feet per mile in the last 74 miles, with frequent concentrations of descent. Tributaries entering the river from the west flow through a clayey-loam soil, but the upper and eastern portions of the drainage area have a sandy-loam soil. It is therefore likely that this river has a fairly uniform flow. The decline of the lumbering interests greatly increases the value of the Red Cedar River as a power producer.

A gaging station was established near Menominee, Wis., June 17, 1907. This station is located on a road bridge west of Menominee, Wis., and 200 rods from the Chicago & North-Western railroad depot.

The general direction of the channel is straight for 500 feet above the station and also for 800 feet below. The water is not swift. The average width is about 200 feet broken by one pier. (Looking down stream.) The right bank is high and wooded and is not liable to overflow but the left bank is not high and during high stages of river the banks will overflow. The bed is composed of sand and gravel but it does not shift.

Discharge measurements are made from this bridge to which the gage is attached. The initial point of sounding is directly over the inside edge of east abutment on the upstream side.

A standard chain gage, which was read by J. H. Noyes during 1907, is fastened to the down stream side of bridge. The length of the chain from the end of the weight to center of marker is 23.65 feet. The gage is referred to the following bench marks:

(1) S. E. corner of east end standard of side walk rail just above abutment. It is 3.36 feet below the zero on gage box and 20.29 feet above datum of gage. This B. M. is indicated by a cross.

(2) A cross made in telephone pole on upstream side of bridge at east end. It is 1.93 feet below zero on gage box and 21.72 feet above datum of gage.

(3) A cross on top of standard of side walk railing at left end of gage box. It is .35 feet above zero of gage box and 24.0 feet above datum of gage.

The following discharge measurements of Red Cedar River have been made at Menomonie, Wis., in 1907.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
1907.						
June 18	G. A. Gray	189	860	1.52	2.85	1,329
July 16	do	196	942	2.59	3.94	2,439
August 20	do	202	991	2.47	4.35	2,439
September 20	do	205	1,210	3.74	5.6	4,548
October 22	do	185	710	1.08	2.42	782
October 22	do	185	656	.97	2.1	657
November 18	do	189	784	1.59	3.0	1,273
December 21	do	180	658	1.02	2.4	686

Mean daily gage height, in feet of Red Cedar River at near Menomonie, Wis., for 1907.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.42	2.83	3.08	3.82	2.95	2.7
2		4.52	2.77	2.98	3.54	3.35	2.47
3		4.62	2.81	2.97	3.40	3.1	2.9
4		3.67	2.71	2.87	3.47	3.15	2.52
5		3.27	2.78	2.79	3.32	2.85	2.47
6		4.06	3.01	2.79	3.22	2.8	2.42
7		3.51	2.91	2.83	3.17	3.1	2.7
8		3.17	2.79	2.77	3.18	.5	2.82
9		3.31	2.75	2.81	3.34	1.4	3.03
10		3.29	2.77	2.86	3.07	2.7	2.95
11		3.13	2.76	2.78	3.27	2.77	2.55
12		2.96	2.65	2.76	3.17	2.72	2.62
13		2.89	2.65	2.75	3.30	2.72	2.47
14		2.83	2.65	2.77	3.35	2.35	2.3
15		3.05	2.67	2.72	2.85	2.52	2.35
16	(1)	4.1	2.72	2.97	3.35	2.5	2.55
17	2.5	5.96	2.71	2.99	3.61	2.95	2.55
18	2.74	5.3	2.67	2.72	2.80	2.95	2.5
19	2.74	4.1	2.72	5.23	2.95	3.0	2.65
20	2.78	3.8	4.42	5.76	2.70	2.85	1.1
21	2.68	3.57	4.27	6.75	3.30	2.76	3.1
22	2.8	3.5	3.87	5.82	3.10	2.82	2.6
23	3.0	4.18	3.45	4.79	2.67	2.95	2.75
24	3.02	3.62	3.07	4.26	2.72	2.82	2.55
25	3.0	3.15	3.03	4.22	2.7	2.85	2.7
26	2.89	3.08	2.99	4.23	2.75	2.9	2.35
27	2.82	2.98	2.88	3.72	2.72	2.75	2.57
28	2.74	2.94	2.90	3.32	2.92	2.82	2.8
29	2.74	2.87	2.86	3.67	2.42	2.77	2.7
30	2.87	2.82	2.99	3.40	2.10	2.50	2.5
31		2.87	3.08		3.03		2.6

[1] Station established.

Water Powers and Dams.—In the 30 miles below Hay River the Red Cedar descends 154.3 feet, and as this region borders the prairie region and is thickly settled, the six powers here included will probably be developed to the full extent in the near future. This development includes: (1) The construction of a dam at Dunnville,

2 miles above the mouth of the river, giving a head of 15.6 feet and an estimated 1,685 horsepower; (2) the raising of the present dam at Downsville 4 feet, giving a total head of 23.2 feet and an estimated 2,480 horsepower; (3) the construction of a dam at Irving, with a total head of 21.9 feet, giving an estimated 2,260 horsepower; (4) the raising of the present dam at Menomonie 2.8 feet, thus obtaining a total head of 18.4 feet and an estimated 1,800 horsepower; (5) the building of a new dam near the "Omaha" bridge, 2.8 miles above Menomonie, with a head of 16.6 feet and an estimated 1,700 horsepower; (6) the raising of the present dam at Cedar rapids 21.3 feet, giving a total head of 40 feet and an estimated 3,800 horsepower.[1] Recently all the powers owned by Knapp, Stout & Co., including many of the most valuable on the river, have been acquired by the Wisconsin Power Company, of Chicago, Ill. The location of 10 dams owned by this company is shown in the following table:

Dams on Red Cedar River owned by the Wisconsin Power Company.

Location.	Head.	Amount of flowage.	Authority.
	Feet.	Cubic feet.	
Sec. 25, T. 37. N., R. 10 W	14.0	1,674,000,000	U. S. engineers.
Sec. 2, 36 N., R. 10 W	7.0	405,000,000	Do.
Sec. 25, T. T. 36, N., 10 W	12 0		
Sec. 30, T. 36 N, R. 9 W	10.0	135,000,000	Do.
Sec. 29, T. 36 N., R. 9 W	10.0		
Sec. 13, T. 34, N., R. 10 W	12.0	40,500,000	Do.
Sec. 30, T. 33, R. 10 W	10.0	810,000,000	Do.
Downsville	19.0		J. W. Orbison.
Menomonee	15.5		Do.
Cedar Falls.	18.7		Do.

Under date of April 9, 1907, E. P. Burch, consulting engineer, writes that the power at Menomonie, Wisconsin, is now being developed at a cost of $200,000. The old dam has been greatly strengthened and its crest raised 3.5 feet, giving a maximum head of 20.5 feet. There is a valuable storage of one square mile above the dam site. The power house will be made of concrete and the machinery now being installed consists of two 600 K. W. generators driven by horizontal twin turbines. This power will be transmitted by the company at Menomonie and Eau Claire, Wisconsin.

Railroads.—Between the mouth of Red Cedar River and Menomonie the Chicago, Milwaukee and St. Paul Railway closely parallels the river. In this stretch of 17 miles are situated the most import-

[1] This statement is based on a careful survey for the owners made by O'Keef & Orbison, hydraulic engineers, of Appleton, Wis., and an estimated run-off of 0.461 second-feet per square mile.

ant powers. Above Menomonie the drainage is crossed by the Chicago, Milwaukee and St. Paul, the Chicago, St. Paul, Minneapolis and Omaha, the Wisconsin Central, and the Minneapolis, St. Paul and Sault Ste. Marie railways.

EAU CLAIRE RIVER.

Ranked in order of its drainage area (900 square miles), Eau Claire River is third among the tributaries of the Chippewa. The greater part of this area is underlain by the Cambrian sandstone, and all except the upper headwaters drain a sandy-loam soil, as will be seen from Plate II. Like most of the neighboring rivers, the Eau Claire has been an important lumbering stream, with many flooding dams. Very few water powers have been utilized. The first developed water power is about 500 feet from the mouth of the river, where a dam 300 feet long develops a head of 11 feet to run a linen mill, which uses only part of the power thus furnished. About 3,000 feet farther upstream is a second dam, with an average head of 13.5 feet, owned by the Northwestern Lumber Company. An installation of turbines of 420 horsepower is reported. This is used in running a saw mill, a machine shop, and dynamos. The same company reports the three following lumbering dams on this river, but none of the resulting water power is utilized at the present time. In the NW. ¼ NE. ¼ Sec. 14, T. 27 N., R. 9 W., is a dam with a 7-foot head, capable at ordinary low water of furnishing 210 theoretical horsepower. In the SW. ¼ NE. ¼ Sec. 13, T. 27 N., R. 8 W., is a timber dam with a head of 8 feet, which could easily and cheaply be increased to 20 feet, thus producing at ordinary low water 540 theoretical horsepower. The third dam, with a present head of 20 feet, is reported in the SW. ¼ SW. ¼ Sec. 5, T. 26 N., R. 6 W. This dam has not been used for many years and is much in need of repairs. There are many other opportunities for developing water powers on the Eau Claire River, as well as on its tributaries.

JUMP RIVER.

As its name would imply, Jump River is a very rapid stream, with numerous falls and rapids, making a descent of nearly 500 feet in its entire length of 65 miles. Its drainage area of 720 square miles is a long and narrow one, and with only a few unimportant exceptions is devoid of lakes and swamps. As a result the river has

a very uneven flow as compared with the Flambeau, which stream it resembles in flowing through a valley whose soil is a clayey loam. The main portion of the Jump River valley has no railroads and is sparsely settled. A branch of the Wisconsin Central is now being built across this drainage. The most important falls on the river, 35 feet in height, are in Sec. 20, T. 34 N., R. 2 W., about 1 mile east of the junction of north and south forks, but there are numerous other dam sites of 15 to 20 foot head, which will doubtless be utilized when this section is settled.

YELLOW RIVER.

The drainage area of Yellow River is 460 square miles, distributed in a long, narrow valley. The lower half of the valley has a sandy soil, the upper part a clayey loam. While the gradient of Yellow River is not so great as that of its neighbor, Jump River, it has a rapid current. As in the case of other rivers in this region the only dams built were for logging purposes. The Miller dam is said to be the only one remaining. Three other dams, one at Colburn, one in Sec. 7, T. 29 N., R. 5 W., and one at Cadott, have all been carried away by floods. The river is crossed by three railroads.

SMALLER TRIBUTARIES.

Chippewa River has a host of smaller tributaries, nearly all of which, because of their rapid currents and high, rocky banks, can be cheaply developed. Duncan Creek is a good example of what can be done with this class of tributaries. Although only 25 miles long, it has five dams with an aggregate head of 68 feet. Four gristmills, with a total turbine capacity of over 500 horsepower, take their power from this creek. Below the "Star mills," in the city of Chippewa Falls, is an unimproved poyer of 14-foot head; and immediately below this site is a dam with a 9-foot head, belonging to the Gatzian Shoe Manufacturing Company. The significant point regarding powers of this class is that they are cheaply improved and very widely distributed. The locations of some of them are shown in the following table: Plate XL gives a view of the Glen mill dam.

DAM ON DUNCAN CREEK, GLEN MILLS.
Head, 20 feet.

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Dams on smaller tributaries of Chippewa River.

Location.	Owner and use.	Head.	Installation.
		Feet.	H. P.
Arkansaw Creek, Arkansaw	Mills & Son, gristmill	12	25
Bass Creek, Afton	Wm. Denoger, flouring mill	9	40
Bear Creek, Durand	Durand roller mill, flour	18	73
Bridge Creek:			
Augusta	Dells Milling Co., flour	20	60
Sec. 18, T. 26, R. 6 W	F. P. Waddell	20	(*)
Duncan Creek:			
Chippewa Falls	Gotzian Shoe Co	9	(†)
Do	Leinenkugel Brewing Co	14	(*)
Do	Leinenkegel Co., flour	16	350
Sec. 31, T. 29 N., R. 8 W	Glen Mills, flour	20	100
Sec. 24, T. 29 N., R. 9 W	G. W. Lockin, Tilden flouring mills	10	70
Sec. 8, T. 30 N., R. 9 W	Bloomer mills, flour	12	30
Eighteenmile Creek, Colfax	J. A. Anderson & Son, grist and saw mill	14	60
Hay River, Prairie farm	P. F. Milling Co., grist	9	.....
Jump River:			
Sec. 20, T. 34 N., R. 2 W	...	35	(*)
Westboro	.....	.....	.....
Lowes Creek, sec. 4, T. 26 N., R. 9 W	W. J. Davis	‡30	.....
O'Neals Creek:			
Sec. 26, T. 31 N., R. 9 W	Wm. Durch, grist and saw mill	8	30
Near mouth	F. G. & C. A. Stanley, saw mill	22	50
Eagle Point	M. Rosmus, electris light	12	150
Otter Creek, Eau Claire	R. Clark, flour	18	95
Pine Creek:			
Lucas	T. Teegarden, grist and saw mill	12	80
Sand Creek	A. F. Johnson, grist and saw mill	6	96
Dalles	J. A. Anderson, grist and saw mill	8	50
Rock Creek, sec. 22, T 27 N., R. 11 W	D. W. Andrews, flour	35	75
Tiffany Creek, Boyceville	A. A. Hoyr & Bro., grist	9	30

* Undeveloped. † Unused. ‡ Could be raised eight feet.

ST. CROIX RIVER SYSTEM.

TOPOGRAPHY AND DRAINAGE.

St. Croix River rises at an elevation of 1,010 feet, in St. Croix Lake, on the Lake Superior divide, only 20 miles from Lake Superior. The lower two-thirds of its length forms a part of the Minnesota boundary. In its total length of 168 miles it descends 344 feet, all but 20 feet of which is in the upper 116 miles, making the average for this upper portion nearly 3 feet per mile. This slope is fully six times the slope of Mississippi River above Minneapolis, and, according to United States engineers, has an important bearing on the relatively large run-off as compared with Mississippi Valley above. Another important feature of this region is its relatively small number of lakes, these forming only 3 per cent of the total drainage area as compared with 11 per cent in Mississippi Valley above Minneapolis. Evaporation on lake surfaces is probably nearly equal to the precipitation for the corresponding period. The total drainage area comprises 7,576 square miles, the greater part of which is in Wisconsin. The Wisconsin portion has a width of 50 miles on its northern margin and extends southwesterly toward Mississippi River, a distance of about 150 miles. Plate XLI shows the form and extent of the drainage area.

The topography may be described under three heads—(1) the level area, (2) the rolling and swelling hill districts, and (3) the knoll and basin combination. The first includes the so-called "barrens" which border the streams and some elevated plateaus, together with smaller scattered areas. The third class may be described as a belt lying near the southeastern watershed and stretching from the vicinity of Lake Namekegon southwestward to the St. Croix. The second class includes most of the territory which remains.

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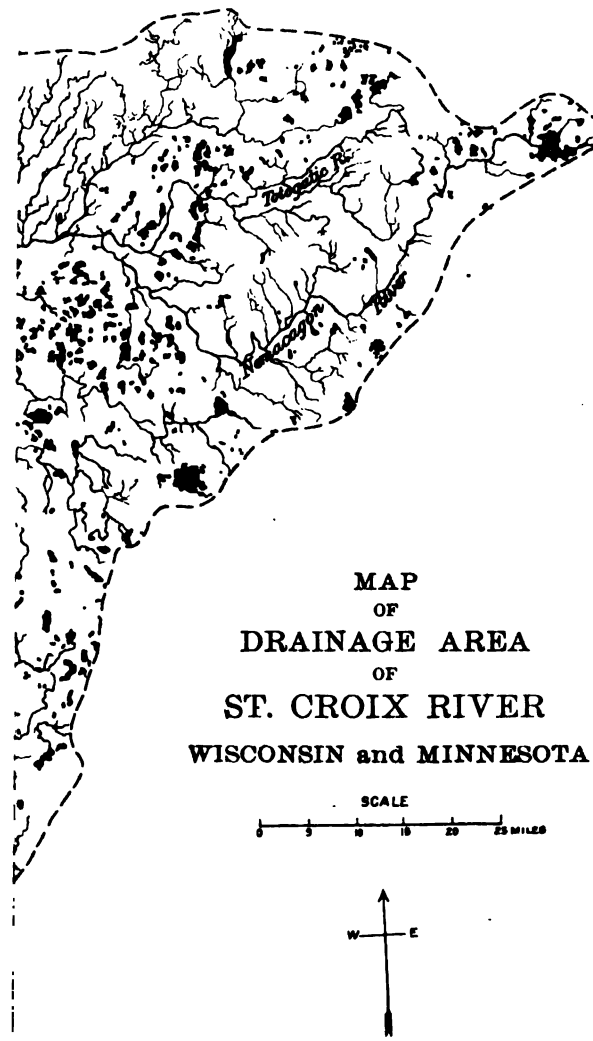
MAP
OF
DRAINAGE AREA
OF
ST. CROIX RIVER
WISCONSIN and MINNESOTA
SCALE
0 5 10 15 20 25 MILES
W
E

Marshes are quite as infrequent as the lakes and occur only on the river bottoms. Not half of the lakes are visibly connected with the rivers, but because of the open soil they are likely to have underground connection. There are usually lumbering dams on such lakes as have outlets, and these lakes, together with the numerous smaller depressions, play an important part in the preventing of freshets. The lakes of this region arrange themselves into two groups—one, lying mostly in the "barrens," adjacent and parallel to the upper St. Croix and extending southwest from its source to the point where the stream turns southward, and a second group in the extreme southeastern portion of this region, occurring in the depressions of the "Kettle moraine." As the water of this region flows almost exclusively over the crystalline rocks and sandstones, or the drift derived from them, it is in general soft, though usually amber colored. Springs are very common, many of the lakes being fed almost entirely by them. They are especially frequent in the Cambrian sandstone and tend to equalize the flow of all the streams.

The apportionment of drainage areas is shown in the following table:

Distances and drainage areas of St. Croix River.

River.[a]	Distance from source (map measure.)	Drainage area above station.
	Miles.	Sq. miles.
St. Croix, source		
Eau Claire:		
Above mouth	6.5	117
Mouth	6.5	224
Namekagon	39.0	1,451
Yellow	50.0	2,084
Clam:		
Above mouth	64.0	2,428
Mouth	64.0	2,844
Kettle:		
Above mouth	75.0	3,046
Mouth	75.0	4,139
Snake	79.0	5,097
Wood	84.0	5,281
Sunrise	100.0	5,857
St. Croix, St. Croix rapids	120.0	6,202
Apple	138.0	6,951
Willow	151.0	7,301
St. Croix, mouth	168.0	7,576

[1] Station is at mouth of river, unless otherwise stated.

Profile of St. Croix River from its mouth to St. Croix Lake.[2]

Station.	Distance.		Elevation above sea level.	Descent between points.	
	From mouth.	Between points.		Total.	Per mile.
	Miles.	Miles.	Feet.	Feet.	Feet.
Prescott, mouth of river	0.0	.....	[1]667.0	.....	.....
Kinnikinnic River, mouth	5.0	5.0	668.0	1.0	0.2
Apple River, mouth	28.0	23.0	672.0	4.0	.2
Osceola	42.0	14.0	683.0	11.0	.8
St. Croix Falls (head of navigation)	48.0	6.0	687.0	4.0	.7
Stt. Croix Falls (crest of dam)	.....	.....	750.0	63	.....
Trade River, mouth	60.0	12.0	753.0	3.0	0.2
Sunrise River, mouth	65.0	5.0	758.5	5.5	1.1
Rush City, ferry	75.0	10.0	773.0	14.5	1.4
Sec. 35, T. 38 N., R. 20 W.	79.0	4.0	±782.0	8.8	0.6
Snake River, mouth	86.0	7.0	±790.0	8.0	1.1
Kettle River rapids, fott	89.0	3.0	±801.0	11.0	3.7
Kettle River, mouth	90.0	1.0	±816.0	15.0	15.0
Kettle River rapids, head (proposed U. S. dam, sec. 2, T. 39 N., R. 19 W.)	93.0	3.0	±850.0	34.0	11.3
Clam River, mouth	101.0	8.0	±868.0	18.0	2.2
Sec. 1, T. 40 N., R. 18 W.	103.5	2.5	874.0	6.0	2.4
Yellow River, mouth	115.0	11.5	888.0	14.0	1.2
Namekagon River, mouth	127.0	12.0	908.0	20.0	1.7
Moose River, mouth	139.0	12.0	1,001.0	93.0	7.7
Sec. 35, T. 44 N., R. 13 W.:					
Below dam	144.0	5.0	1,001.5	.5	.1
Above dam	144.0	.0	1,005.3	3.8	.....
St. Croix Lake	160.0	16.0	1,010.0	4.7	.3

[1] Low-water elevation. [2] From levels run by the U. S. Engineers.

GEOLOGY.

Almost the entire watershed has been glaciated to such an extent that outcrops, except near the rivers, are very infrequent. According to the reports of the Wisconsin Geological Survey, the central and by far the greater portion of this area is underlain by the pre-Cambrian crystalline rocks known as the "Keweenawan." This belt narrows toward the south, giving way both on the east and west to the Cambrian sandstones. These pre-Cambrian crystalline rocks intersect St. Croix River at St. Croix Falls, and because of their greater hardness have caused the falls and rapids—the most important on the entire river—which extend for 6 or 7 miles above the city of Taylors Falls, Minn.

RAINFALL AND RUN-OFF.

The United States Geological Survey maintained a gaging station 3.5 miles above St. Croix Falls, Wis., during 1903. The gage heights are referred to four iron pins on the right bank just below the gaging station, the elevations of which are referred to the datum of the bench marks of the St. Croix River survey. Their elevations are as follows:

	Feet.
Pin No. 1	732.08
Pin No. 2	734.54
Pin No. 3	736.10
Pin No. 4	737.57

A small number of measurements were obtained during 1903, and the gage was read daily by V. H. Caneday. Discharge measurements were made from a boat held in place by a wire cable stretched across the river between two trees. The initial point for soundings is a vertical rod on the left bank. The channel is straight for about 800 feet above and 1,000 feet below the station, while the banks are high and can not overflow. The section is regular, smooth, and permanent, and the velocity is never sluggish, making this on the whole a station at which good results are obtainable. The drainage area at this point is 6,370 square miles.

Discharge measurements of St. Croix River near St. Croix Falls, Wis., in 1903.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	Second feet.
May 22	E. Johnson, jr	4.00	10,747
August 11	W. R. Hoag	2.70	7,470
October 9	L. R. Stockman	3.84	10,244

Discharge data relating to St. Croix River near St. Croix Falls, Wis., obtained through the United States Geological Survey, have been supplemented by data supplied by Loweth & Wolf, civil engineers, of St. Paul, Minn. A record of their gage readings is given in the following tables.

Daily discharge, in second-feet, of St. Croix River near St. Croix Falls, Wis., January 10, 1902, to December 31, 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	.....	.....	1,820	2,425	2,910	3,930	5,150	6,690	2,270	1,725	2,330	5,190	2,430
2	.....	.....	1,875	2,442	2,840	4,090	5,010	4,490	1,740	1,730	2,390	3,950	2,555
3	.....	.....	1,930	2,460	300	3,910	4,480	4,830	1,790	1,680	2,395	3,290	.....
4	.....	.....	1,700	2,300	400	3,920	9,798	4,700	1,825	1,840	1,685	4,740	.....
5	.....	.....	1,760	2,370	2,750	3,985	11,871	7,350	1,870	1,700	2,150	3,910	.....
6	.....	.....	1,755	2,400	2,615	4,900	10,956	5,200	2,035	2,560	2,445	4,180	.....
7	.....	.....	1,750	2,270	2,280	3,980	10,610	12,106	2,280	2,550	2,390	4,030	.....
8	.....	.....	1,770	.....	2,280	4,880	.....	11,698	1,980	2,220	2,290	4,740	.....
9	.....	.....	1,765	.....	2,190	4,560	9,261	11,137	1,660	4,110	2,050	4,500	.....
10	.....	1,895	1,760	.....	2,110	4,560	10,468	12,947	1,990	3,500	930	3,290	.....
11	.....	1,910	1,750	.....	1,990	4,450	6,810	8,978	3,970	1,720	2,950	2,980	.....
12	.....	1,880	1,750	.....	1,870	5,850	7,600	7,980	1,690	1,500	1,950	3,195	.....
13	.....	1,850	1,815	.....	1,468	6,150	8,289	6,700	1,120	1,640	2,040	4,300	2,370
14	.....	1,685	1,870	.....	2,065	5,250	4,780	6,060	1,015	1,550	2,000	4,530	2,260
15	.....	1,765	1,990	.....	2,020	4,780	6,350	5,780	1,570	1,355	1,915	4,900	2,150
16	.....	1,775	1,990	.....	2,170	4,875	4,220	4,860	1,590	1,355	800	4,630	2,080
17	.....	1,795	1,990	.....	2,070	4,820	3,420	4,380	1,560	1,540	845	4,700	2,015
18	.....	1,880	1,990	.....	5,160	4,940	3,580	3,800	1,500	1,480	3,600	4,580	2,110
19	.....	1,860	1,990	4,650	1,510	5,065	6,350	5,210	1,510	1,120	1,940	5,160	2,180
20	.....	1,920	1,990	4,995	1,005	5,300	3,780	2,850	1,500	510	1,925	3,690	2,085
21	.....	1,875	1,990	4,650	500	5,970	960	3,405	1,480	2,800	2,040	4,665	2,040
22	.....	1,930	1,990	4,600	5,540	7,080	3,300	3,530	1,480	2,070	1,980	4,160	2,000
23	.....	1,860	2,027	4,035	440	9,600	3,400	3,600	1,575	2,540	2,040	4,250	2,090
24	.....	1,950	2,065	3,470	510	7,250	6,000	3,185	1,495	2,365	850	4,060	.....
25	.....	1,985	2,110	3,110	1,050	6,420	3,560	2,560	1,405	1,065	1,100	3,730	.....
26	.....	1,975	2,180	3,117	2,760	5,565	4,145	7,250	3,850	1,135	2,300	3,555	.....
27	.....	1,950	2,260	3,125	3,025	5,760	4,380	850	1,860	1,120	2,310	3,680	.....
28	.....	1,930	2,480	3,125	3,290	5,090	4,200	750	1,740	3,060	2,660	3,060	.....
29	.....	1,920	.....	3,125	3,480	6,070	2,550	2,515	1,465	2,210	2,890	3,070	2,080
30	.....	1,905	.....	3,037	3,750	4,930	4,690	2,515	5,995	2,310	1,875	2,050	2,060
31	.....	1,890	.....	2,950	.....	5,290	.....	2,610	1,795	.....	2,840	.....	2,045

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1903.												
1	2,055	1,950	1,940	6,770	8,920	7,680	251	4,750	.....	.....	.....	.....
2	1,940	1,935	1,920	9,800	9,556	10,420	3,030	4,800	.....	.....	.....	.....
3	1,940	1,760	1,920	10,750	.....	(9,490)	.....	5,050	.....	.....	.....	.....
4	1,910	1,830	1,960	12,220	.....	8,560	.....	6,170	.....	.....	.....	.....
5	1,880	1,900	1,965	.....	15,200	7,910	.....	6,710	.....	.....	.....	.....
6	1,930	2,015	1,885	10,350	15,611	7,340	8,640	1,600	.....	.....	.....	.....
7	1,945	1,930	1,990	8,850	15,176	(6,805)	.....	7,900	.....	.....	.....	.....
8	2,010	1,915	2,050	11,645	13,835	6,270	8,880	(7,600)	.....	.....	.....	.....
9	1,930	1,895	2,110	17,975	12,150	6,010	10,155	(7,280)	.....	.....	.....	.....
10	1,850	1,945	.....	16,438	.....	5,760	10,870	7,170	.....	.....	.....	.....
11	1,875	1,950	.....	18,272	9,245	5,160	11,030	4,830	.....	.....	.....	.....
12	1,900	1,880	.....	20,166	16,157	6,190	(10,437)	5,510	.....	.....	.....	.....
13	1,930	1,975	.....	.....	.....	7,320	9,245	5,340	.....	.....	.....	.....
14	1,950	1,930	.....	.....	.....	(6,910)	7,250	5,350	.....	.....	.....	.....
15	1,980	1,870	.....	15,382	.....	6,500	7,200	(4,792)	.....	.....	.....	.....
16	1,870	1,840	.....	14,080	.....	5,825	6,015	4,235	.....	.....	.....	.....
17	1,770	1,870	4,030	12,800	.....	5,130	6,790	4,150	.....	.....	.....	.....
18	1,815	1,970	4,530	.....	.....	5,755	6,035	3,400	.....	.....	.....	.....
19	1,870	1,850	6,480	12,540	.....	4,300	(5,572)	3,580	.....	.....	.....	.....
20	1,780	1,700	9,890	10,260	13,830	.....	5,150	4,300	.....	.....	.....	.....
21	1,980	1,745	11,440	.....	13,790	.....	4,540	4,740	.....	.....	.....	.....
22	1,730	1,830	11,460	.....	10,580	1,542	4,375	.....	.....	.....	.....	.....
23	1,820	1,910	11,480	.....	11,230	2,700	3,900	3,220	.....	.....	.....	.....
24	1,800	1,950	10,740	6,800	11,665	2,710	1,830	.....	.....	.....	.....	.....
25	1,865	1,945	9,660	9,740	12,100	2,640	5,500	.....	.....	.....	.....	.....
26	1,930	1,820	10,100	9,265	9,850	2,545	(4,670)	.....	.....	.....	.....	.....
27	1,900	1,880	9,530	8,790	12,020	(2,475)	3,750	.....	.....	.....	.....	.....
28	2,050	1,970	8,725	10,460	12,640	(2,420)	4,770	.....	.....	.....	.....	.....
29	1,980	.....	8,590	10,080	11,420	2,370	4,730	.....	.....	.....	.....	.....
30	1,835	.....	8,445	8,925	10,640	907	4,485	.....	.....	.....	.....	.....
31	1,970	.....	8,160	.....	(9,160)	.....	4,570	.....	.....	.....	.....	.....

Daily discharge, in second-feet, of St. Croix River near St. Croix Falls, Wis., January 10, 1902, to December 31, 1904—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	2,390	2,110	2,580	5,560	8,400	6,340	6,170	840	.....	3,950	8,780	1,690
2	2,390	2,000	2,570	6,130	7,590	5,520	5,850	1,080	4,530	(3,840)	8,040	1,760
3	.....	2,060	2,520	(7,000)	7,540	6,050	(3,630)	1,480	4,610	3,720	7,590	2,210
4	.....	2,040	2,390	8,080	7,480	7,950	1,410	3,460	(4,750)	3,360	6,780	(2,400)
5	.....	2,080	2,290	9,873	7,380	(12,560)	(3,010)	2,250	4,900	11,310	3,280	2,620
6	.....	2,070	2,390	12,390	8,290	17,180	4,610	1,990	4,870	1,240	(4,230)	2,740
7	3,660	(2,040)	2,490	15,930	8,790	17,920	4,780	2,040	5,040	(2,800)	5,230	2,890
8	3,140	2,020	2,600	16,900	(10,320)	17,460	4,610	2,100	4,690	4,690	5,440	2,970
9	2,810	2,160	2,590	18,300	(11,850)	15,650	4,970	2,210	4,600	(3,400)	5,700	2,770
10	(2,820)	2,110	2,560	(16,600)	13,370	12,940	2,960	2,100	(4,030)	2,120	4,900	2,820
11	2,840	2,000	2,590	15,060	11,300	12,610	950	2,000	(3,460)	10,430	5,330	(2,820)
12	2,600	2,160	2,640	14,010	9,490	(12,070)	3,480	2,300	2,820	15,020	5,600	2,830
13	2,340	2,000	2,650	10,590	8,550	11,530	3,860	2,340	(2,380)	14,270	(5,540)	2,500
14	2,660	(2,140)	2,660	7,910	8,080	11,320	3,750	(1,750)	1,940	13,800	5,470	2,420
15	2,680	(2,280)	2,700	12,560	8,650	7,880	3,890	1,150	2,150	12,560	5,250	2,220
16	2,680	2,430	2,740	10,010	8,310	8,540	3,990	950	3,480	.....	4,970	2,380
17	(2,410)	2,430	2,690	(9,460)	7,280	7,628	(2,530)	1,430	3,190	10,060	4,770	2,330
18	2,200	2,460	2,700	(8,920)	7,820	8,140	1,080	3,370	(3,160)	10,760	4,570	2,320
19	2,480	2,410	2,750	8,380	6,800	8,710	1,140	1,920	3,140	10,310	4,480	2,300
20	2,460	2,450	(1)	7,850	5,250	9,280	3,760	2,240	2,890	12,710	(4,340)	2,380
21	2,440	(2,370)	.....	7,490	6,390	6,730	3,420	(3,760)	2,750	(15,700)	4,190	2,160
22	2,680	2,290	.....	7,580	(6,900)	5,630	3,170	5,290	2,380	18,700	4,020	2,440
23	2,620	2,330	.....	11,260	(7,500)	5,820	3,270	4,390	2,490	(18,010)	4,000	2,340
24	(2,570)	2,230	.....	(19,810)	8,000	4,960	(2,240)	2,520	2,700	17,330	4,120	2,390
25	2,520	2,280	.....	10,360	7,790	5,190	1,210	2,970	(3,240)	16,180	3,720	(2,420)
26	2,330	2,410	3,090	11,170	8,760	(3,380)	1,050	2,510	3,790	15,540	3,710	2,450
27	2,390	2,460	(3,370)	11,230	8,030	1,570	2,580	2,480	3,330	12,710	(3,300)	2,460
28	2,280	2,480	3,660	10,769	7,390	4,850	2,780	(2,230)	3,500	12,910	2,890	(2,440)
29	2,270	2,520	3,300	10,850	(6,700)	5,330	2,720	1,960	3,580	10,590	2,800	(2,420)
30	2,250	.....	3,770	9,490	6,060	5,320	2,810	2,200	(3,880)	(10,410)	(2,250)	(2,400)
31	.....	.....	4,510	.....	6,440	.....	.....	(3,000)	.....	10,230	.....	2,380

[1] March 20 to 25, ice going out.

Estimated monthly discharge of St. Croix River at St. Croix Falls, Wis., for 1902, 1903, and 1904.

[Drainage area, 6,370 square miles.]

Date.	Discharge.			Run-off		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
	Sec.-feet.	Sec.-feet.	Sec.-feet.	Sec.-feet.	Inches.	Inches.
1902.						
January	1,960	1,680	1,880	0.31	0.36	0.90
February	2,480	1,700	1,880	.31	.36	.54
March	5,000	2,380	3,300	.60	.69	.69
April	5,500	200	2,220	.37	.41	2.08
May	9,000	4,100	2,020	.33	.38	3.09
June	11,870	960	5,950	.99	1.14	3.59
July	12,106	760	5,500	.92	1.06	6.30
August	6,000	1,020	1,860	.31	.33	2.82
September	4,100	400	1,880	.31	.36	3.26
October	3,600	800	2,000	.33	.38	1.58
November	5,200	2,500	4,080	.68	.77	2.76
December	2,550	2,020	2,100	.35	.40	2.16
The year	12,106	200	2,912	.48	6.67	29.77

[1] This is the average of the recorded precipitation at Barron, Duluth, Grantsburg, Hayward, Osceola and St. Paul.

Estimated monthly discharge of St. Croix River at St. Croix Falls, Wis., for 1902, 1903 and 1904—Continued.

[Drainage area 6,370 square miles].

Date.	Discharge.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Per square mile.	Depth.	
	Sec.-feet.	Sec.-feet.	Sec.-feet.	Sec.-feet.	Inches.	Inches.
1903.						
January	2,040	1,740	1,920	.32	.37	.59
February	2,020	1,700	1,880	.31	.36	.83
March	11,480	1,960	5,600	.92	1.05	1.97
April	20,185	5,800	12,000	2.00	2.30	2.78
May	16,157	8,920	12,700	2.12	2.43	5.78
June	7,900	906	5,050	.84	.96	1.69
July	11,620	251	6,360	1.06	1.21	6.75
August	7,900	1,600	4,850	.81	.92	4.77
September	14,918	6,960	11,750	1.96	2.26	7.27
October	29,611	5,740	12,780	2.13	2.44	4.11
November	7,000	850	4,270	.71	.81	.66
December	3,440	2,340	2,740	.46	.52	.97
The year	29,611	[2]251	6,816	1.14	15.63	38.22
1904.						
January	2,840	2,200	2,600	.43	.48	.64
February	2,480	2,000	2,238	.37	.42	1.18
March	4,510	2,290	2,832	.47	.53	1.19
April	18,300	5,560	10,748	1.79	2.01	1.65
May	13,370	5,250	8,176	1.36	1.53	3.78
June	17,920	4,850	8,868	1.48	1.66	5.58
July	5,850	950	3,145	.52	.58	4.64
August	3,460	840	2,334	.39	.44	3.84
September	5,040	1,940	3,544	.59	.66	5.75
October	18,700	1,240	10,560	1.76	1.98	5.47
November	8,790	2,800	4,843	.80	.90	.05
December	2,970	1,690	2,441	.40	.45	.99
The year	18,700	840	5,194	10.36	11.65	34.77

[2] Low water due to the manipulation of a lumbering dam a few miles above.

Water Powers.

FALL.

In the lower 48 miles of its course the St. Croix River has its bed in the Cambrian sandstone or "Lower Magnesian" limestone, principally the former, which it has succeeded in wearing down nearly to base-level, giving steamboat navigation from Taylors Falls, Minn., to Mississippi River. Its descent in this distance of 48 miles is only 20 feet at low stages, nearly all of which is found in the upper half between Stillwater and Taylors Falls. At Stillwater, 223 miles above the mouth of the river, the sandstone bluffs rise steeply on either side to a height of 150 to 200 feet, and the river rapidly narrows. The

bluffs continue, generally with a flat on one side, between Taylors Falls and Stillwater. In the 24 miles below Stillwater the river averages about half a mile in width, with a maximum of 7,000 feet at the expansion of the river known as St. Croix Lake, below Stillwater. For several miles here, according to reports of United States engineers, the river is almost without gradient.

The portion of the St. Croix above Taylors Falls abounds in undeveloped powers. Except near the headwaters of St. Croix, Totogatic, and Namekagon rivers and a small area served by a branch line of the Northern Pacific, running to Grantsburg, this region is without railroad facilities. The following detailed description of the main river above St. Croix rapids, taken from the Tenth Census, 1880, gives the most trustworthy information of the region obtainable:

"From the mouth of the Eau Claire to that of the Namekagon River there is a descent of 100 feet, or 4 feet per mile, and many rapids occur, among which Copper Mine rapids may be mentioned. Above the mouth of the Namekagon the ordinary low-water power under a head of 10 feet would be 150 horsepower. The Namekagon River increases this to 600 horsepower.

In the 12 miles from the mouth of the Namekagon to the Yellow River the total fall is 20 feet, including Big Island rapids, State Line rapids, and Bishops rapids. Each of the first two is described as affording fine opportunities for developing water powers. At Big Island rapids the river runs close to the bluffs on the left bank, but a dam would need to extend some distance across the flat on the right.

From the mouth of the Yellow River to the head of Kettle rapids, a distance of 21 miles, the average slope is 1.8 feet per mile, there being no rapids of special importance. It is very probable that available water-power sites can be found in this section.

St. Croix Rapids.—These rapids are located near the village of St. Croix Falls but a short distance above the head of navigation on the St. Croix river. The bed of the river is in the hard trap rock, and the banks rise abruptly, especially on the Wisconsin side.

Formerly a dam was maintained here with a head of about 25 or 30 feet but it has long ago gone to ruin. There is a total descent of about 55 feet in the six miles which may be included under the name of St. Croix rapids.

[1]In February, 1903, Congress passed the bill authorizing the con-

[1]This description is condensed from "The Commercial West" of December 15, 1906.

struction of a dam at this site and the legislatures of Wisconsin and Minnesota promptly granted a charter. Under this authority construction work was begun in the spring of 1905, and continued until its completion in the fall of 1906. The dam is 50 feet high and 750 feet long, all built of concrete in which are imbedded huge pieces of solid rock. The power station is located on the back or down stream side of the dam on the Wisconsin side of the river. Owing to the low ground above the village of Taylors Falls, Minnesota, it was necessary to construct a concrete dyke 1,000 feet long and 20 feet high. Plate XLII shows a view of the completed dam and power plant.

This completed plant calls for a development of 27,000 h. p., of which one-half is already provided for and the remainder of the turbine equipment will be installed as occasion demands.

From the forebay the water goes into the iron penstocks of which there are 8, each 14 feet in diameter, providing one for each generator and two penstocks, 4 feet in diameter for the exciters. The generator water wheels are of the Victor type, 36 inches in diameter with four runners to a unit. The exciter water wheels are 18 inches in diameter with one runner to each unit.

The water wheel governors are of the Lombard type, one being supplied to each water wheel. Each governor is able to exert a pressure of 8 tons in opening and closing the water gates. Each of the four large water wheels already installed is directly connected to a Westinghouse generator capable of continuously developing 2,500 kilowatts or 3,300 h. p., and 3,125 kilowatts or an overload of 25% for two hours. Each of the large generators is connected to a bank of three 900 kilowatt Westinghouse transformers which step up the voltage from 2,300 to 50,000 volts.

This power is electrically conducted to Minneapolis 40 miles distant on a private right of way 60 feet wide which was purchased outright. This plant is owned and operated by the Minneapolis General Electric Company. Its cost is given as $3,500,000.

Kettle River Rapids.—[1]Next to the St. Croix Rapids the Kettle River rapids are the most prominent on the river. They extend from a point 2.5 miles above the mouth of the Kettle River to a point 1.5 miles below it. In this distance of 4 miles the total fall is 49 feet, of which 34 feet is above the mouth of the Kettle River. Two islands

[1] Condensed from the Tenth Census.

ST. CROIX FALLS DAM AND POWER HOUSE.
Head, 50 feet. Cost $3,500,000. 27000 h. p.

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from 1 to 2 miles long divide the river into two channels. The bed of the river is in granite rocks and it is practical to build several dams. Above the mouth of the Kettle River a head of 10 feet would afford 1,280 theoretical h. p., with the ordinary low water flow, and below the entrance of Kettle River 1,737 theoretical h. p., under the same conditions of flow.

Above the mouth of Snake River, which enters 4.5 miles below Kettle River, there is 11 feet fall from the foot of the rapids. Between Snake River and St. Croix rapids are the following rapids:

The Otter Slide, just below the mouth of Snake River, the ordinary low-water power of which is estimated for a ten foot head at 2,140 theoretical h. p.; the Horse Race, one mile below; the Baltimore Rapids a mile below the mouth of Wood River, the ordinary low-water power of which under a 10 foot head is 2,220 theoretical h. p.; the Upper Big Rock Rapids, about one mile below them and the Yellow Pine Rapids about 3 miles above the mouth of Sunrise River. The total fall from the mouth of Snake River to St. Croix Rapids is 111 feet and the average slope is 2.64 feet per mile. This insures opportunities for important powers at reasonable expense, but as yet the only dam for power purposes is the St. Croix Falls dam described above.

Tributaries of St. Croix River.

LENGTH AND DRAINAGE.

The length and drainage area of the principal tributaries of St. Croix River, including those entering from the western (Minnesota) side, are shown in the following table:

Principal tributaries of St. Croix River.

River.	Length (map measure.)	Drainage area.
	Miles.	Sq. miles.
Eau Claire	25	107
Namekagon	85	1,002
Yellow	50	310
Clam	50	416
Kettle (Minnesota)	70	1,093
Snake (Minnesota)	78	937
Wood	30	168
Apple	55	427
Willow	35	246

YELLOW RIVER.

Yellow River rises in a large lake called Mud Lake, at an elevation of 1,085 feet,[1] and after a sinuous course of 50 miles joins the St. Croix at a point only half this distance from the source and at an elevation of 888 feet. This gives a descent of 197 feet, an average of nearly 4 feet per mile. This high gradient results in rapids at frequent intervals throughout its entire course. The slope in the upper third of its length is about 120 feet. Here springs and creeks are numerous. The river is known to have a remarkably constant stage, the natural rise and fall during the year varying only from 1.5 to 3.5 feet. This fact may be attributed to the springs and to the regulating effect of the large lakes, especially Yellow Lake, through which it flows. "Its valley is generally narrow, being from 200 to 800 feet in width, although in some places it widens into tamarack marshes of considerable extent. The first banks have a general elevation of 15 feet above low water, running back into high, broken ridges, covered with white Norway and jack pine. Little stone and few bowlders are found until reaching the rapids below Yellow Lake, which are almost continuous to the mouth of the stream."[1]

Near the mouth of the river the banks are high. A dam could be built in Sec. 27, T. 41 N., R. 16, which would develop a head of 25 feet or more and still not back the water up to the Yellow Lake dam. This power could be combined in the same plant with that furnished by Loon Creek, which enters Yellow River near the proposed dam. Loon Creek is said to descend 50 to 75 feet in a distance of 1.5 miles and is therefore of considerable importance. A dam could also be located in Yellow River about a mile above Yellow Lake, which would develop a head of 20 feet by overflowing some good meadow lands between Yellow and Devils lakes.

The following profile of Yellow River suggests the possibility of developing other powers on this river because of its high gradient in ranges 14 and 13:

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[1] Rept. Chief Eng. U. S. Army, 1880.
[1] Rept. Chief Eng. of U. S. Army, 1880.

Profile of Yellow River from its mouth to Mud Lake dam.[1]

No.	Station.	Distance.		Elevation above sea.	Descent Between Points.	
		From mouth.	Between points.		Total fall.	Per mile.
		Miles.	*Miles.*	*Feet.*	*feet.*	*feet.*
1	Mouth of river	.....	.....	888.0	.....	.....
2	Yellow Lake dam	7.0	7.0	928.0	40.0	5.7
3	SW. ¼ sec. 2, T. 39 N., R. 16 W.	15.0	8.0	938.4	10.4	1.3
4	Rice Lake dam (SW. ¼ sec. 16, T. 39, N., R. 14 W)	34.0	19.0	969.4	31.0	1.6
5	SE. ¼ sec. 25. T. 39, N., R. 14 W.	39.5	5.5	994.4	25.0	4.5
6	Sec. 31 (near north ¼ stake), T. 39 N., R. 13 W.	40.5	1.0	1,004.8	10.4	10.4
7	SW. ¼ sec. 32, T. 39, N., R. 13 W.	41.5	1.0	1,011.6	6.8	6.8
8	Harts (SE. ¼ sec. 5, T. 38 N., R. 13)	42.5	1.0	1,019.0	8.4	8.4
9	Sec. 36 (near north-south ¼ line), T. 39 N., R. 13 W.	47.5	5.0	1,046.8	27.8	5.6
10	Spooner	49.0	1.5	1,058.0	11.2	7.5
11	Mud Lake dam (above)	52.0	3.0	1,085.0	27.0	9.0

[1] Authority: Nos. 1-9 and 11, U. S. engineers; 10, Chicago, St. Paul, Minneapolis and Omaha Rwy.

Important logging dams are described by United States engineers as follows:

Logging dams on Yellow River.

Name.	Location.	Head.	Capacity.	Remarks.
		Feet.	Cubic feet.	
Mud Lake dam	Sec. 27 T. 39 N., R. 12 W	7.5	475,000,000	
Hector dam	Sec. 10 T. 38 N., R. 13 W	7.5	.....	Small capacity.
Rice Lake dam	Sec. 20 T. 39 N., R. 14 W	10.0	700,000,000	Head could be increased to 15 feet.
Yellow Lake dam	Sec. 7, T. 40 N., R. 16 W	18.0	1,400,000,000	Raises water in Yellow Lake 3 feet.

EAU CLAIRE RIVER.

Eau Claire River has its sources in lakes of the same name at an elevation of 1,122 feet[1] above sea level. These lakes are surrounded by high banks, so that at small expense a dam could be constructed at their outlet and made to store surplus waters, thus adding greatly to all water power on the river. In its short length of 25 miles this river descends 118 feet, including several rapids, 46 feet of this descent being concentrated in the first 6 miles below Eau Claire Lakes. The total drainage area of the river is 107 square miles.

[1] Rept. Chief Eng. U. S. Army, 1881.

APPLE RIVER.

Apple River, like the Willow, occupies a comparatively well-settled valley. It drains an area of 427 square miles. The Wisconsin Central, the Chicago, St. Paul, Minneapolis and Omaha, and the Minneapolis, St. Paul, and Sault Ste. Marie railways are distant 1 to 5 miles from the river, the last-named road crossing it near Amery. The river has its source in 20 or more lakes, the largest 6 miles long and one-half to three-fourths of a mile wide. These lakes tend to equalize and increase the summer flow. The long and severe winters cause the minimum flow during the months of January and February.

Formerly most of the dams on Apple River were used in connection with logging operations, but the timber is now practically all cut. Flouring mills have been maintained at a number of points, and at others the power is used for electric lighting. There are several projects at the present time which look to large improvements of some of these powers. The river in the first and last thirds of its course runs through the Cambrian sand stone, while its middle third is through the "Lower Magnesian" limestone. In the lower third of its course the river flows over a rocky bed between rocky banks, giving ideal conditions for dams. Most of the larger powers occur in this stretch, and some of these, developed and undeveloped, are described below:

1. The first power on the river is an undeveloped one located about 1.5 miles from its mouth. A dam at this point would give a head of 15 feet.

2. The second power, owned by the St. Croix Power Company, is located about 2 miles from the mouth. Here a concrete dam of the arch type, 250 feet long and 47 feet high, develops a head of 82 feet.

3. Four miles from the mouth is a gristmill with a head of 11 feet, owned by E. E. Mason.

4. The next dam, located in Sec. 35, T. 31 N., R. 19 W., develops a head of 18 feet.

5. Another dam, located in Sec. 31, T. 31 N., R. 18 W., with a head of 22 feet is owned, under the name of the Apple River Power Company, by the Western Gas and Investment Company of Chicago, which also owns No. 4 described above.

6. A dam 12 miles above the mouth of Apple River gives a head of 29 feet. The discharge at this point is about 80 per cent of the

total flow measured at the mouth. This power is transmitted electrically to New Richmond, where it is used by mills and elevators.

The powers on Apple River of less importance are described in the following table:

Minor water powers on Apple River.

Location.	Owner and use.	Head.	Remarks.
		Feet.	
Above mouth:			
13 miles	H. L. Bixby, flour	11	Developed.
13½ miles	M. C. Duggies & Jewett	8	Undeveloped.
15¼ miles (Star Prairie)	H. Bixby	....	Do.
25¼ miles	J. C. Schnyder flour	12	Developed.
Sec. 17, T. 12 N., R. 13 W	Winger & Winger	2	Do.
One-half mile above last site	J. Stucky, gristmill	12	Do.
Amery	Northern Supply Co., elevators.	12	One-half total discharge developed.
Blakes Lake	Blake	12	Developed; can be made 18 feet.

There are many other powers above Blakes Lake, with heads of from 6 to 20 feet, mostly old logging dams in poor condition. When the region becomes more settled some of these powers will be improved.

The following data on the discharge of Apple River for the year 1903 are furnished by John Pearson, superintendent of the St. Croix Power Company, Somerset, Wis. The computations are based on the capacity of turbines located at a point 2 miles from the mouth of Apple River. The average daily discharge for each month is as follows:

Estimated daily discharge of Apple River near Somerset, Wis., for 1903.

Month.	Discharge.	Month.	Discharge.	Month.	Discharge.
	Sec.-feet.		Sec.-feet.		Sec.-feet.
January	258	May	860	September	690
February	239	June	468	October	660
March	600	July	492	November	332
April	555	August	380	December	324

WILLOW RIVER.

Willow River, one of the smaller tributaries of the St. Croix, has a high gradient, due to the fact that its bed lies in the "Lower Magnesian" limestone for its entire length. It drains an area of only 246 square miles and has a length of about 35 miles. In the lower two-thirds of this distance, between Hudson and Jewett Mills, it descends 213 feet, giving many opportunities for water power. Many

of these powers are improved, as the river traverses a fairly rich and well-settled country and is paralleled for a considerable distance either by the Wisconsin Central or the Chicago, St. Paul, Minneapolis and Omaha Railway. The powers are here briefly described in order, beginning at the mouth:

1. A timber dam at Hudson 100 feet long gives a head of 16 feet, and with improved machinery would develop 117 horsepower at ordinary low water. A part of this power is used occasionally for electric light when the power described as No. 3 is short of water.

2. Two miles from the mouth of Willow River a dam formerly developed a 9-foot head and was used for driving a flouring mill. At present this dam is washed out.

3. The 130-foot dam of the Willow River Electric Light and Power plant, 3.5 miles from the mouth of the river, gives a head of 22 feet, sufficient to develop 200 theoretical horsepower at ordinary low-water flow. The power is used to generate electricity for lighting the city of Hudson, Wis., and for pumping its water supply.

4. A timber dam 100 feet long, 5.5 miles from the mouth of Willow River, gives a head of 24 feet, sufficient to develop about 125 horsepower. This power is used for a flouring mill. About 1,200 feet below this dam there is a fall of about 47 feet, and at this point a new dam could be erected, which could be made to include the 24-foot dam above, giving a total head of 71 feet. Such a dam would need to be about 26 feet high and about 70 feet or 80 feet long. By carrying the water a short distance below in a penstock, a total head of 105 feet could be secured, sufficient to develop about 600 horsepower at ordinary flow of water. This site, being where the river bed changes from the "Lower Magnesian" limestone to the Cambrian sandstone, affords ideal conditions for a dam. The town of Burkhardt, on the Chicago, St. Paul, Minneapolis and Omaha Railway, is located about a mile distant.

5. Seven miles from the mouth of Willow River a 100-foot timber dam gives a head of 16 feet. This power is used to run dynamos.

6. Rapids occur 8.5 miles from the mouth of Willow River. A dam 125 feet long at this point, located at comparatively small expense in a narrow limestone gorge, could be made to develop a head of 22 feet.

7. At a point about 11 miles from the mouth of Willow River the Boardman flouring mills were formerly located. The 80-foot timber dam at this point was washed out some time ago, but the mill still

stands. If the dam were replaced, a head of 16 feet or more could be easily developed. All the above powers on Willow River are owned by C. Burkhardt, who has the right of flowage wherever needed along this stretch of 11 miles, giving an aggregate descent of nearly 200 feet.

8. The next power on Willow River is located at New Richmond. A timber dam 40 feet long, owned by the New Richmond roller mills, develops a head of 18 feet.

9. The last dam on this stream is located at Jewett, 5 miles east of New Richmond. Power afforded by a 10-foot head is owned by P. Newell & Hennesey and used in a feed mill and sawmill. Above this point Willow River is too small for water-power use.

CLAM RIVER.

Clam River drains an area of 416 square miles. It is formed by two branches—North Fork and South Fork—which unite near the center of the drainage area just above Clam Lake. The river descends about 350 feet in a total length of 50 miles, and, as much of this high gradient is concentrated at rapids, several good opportunities are offered for development. The river flows through a comparatively thinly settled region, which as yet has no railroads. Several railroads, however, cross the margins of the drainage. The following statements regarding its principal water powers are based on information given the writer by Edward L. Peet, editor of the Journal, Grantsburg, Burnett County.

A large, unimproved water power exists in T. 40 N., near the line between Rs. 17 and 18 W. At this point the banks of Clam River are 80 to 150 feet high, and the land which would be flooded is low and of little value. Above the proposed dam the valley bottom will average half a mile wide, with a few expansions to 1.5 miles. The bed of the river is clay and bowlders, mixed with sand. Plenty of timber for the construction of a dam grows in the swamps close at hand. Bowlders are also abundant at the dam site. The levels taken on a recent survey show that this power could be improved in the following ways: A dam 6 rods long at the range line would give a head of 20 feet. A dam 10 rods long built farther downstream would produce a head of 35 feet. By adding a 6 foot embankment for a distance of 20 rods this head could be increased to 28 feet; or a dam 60 rods long could be built across the valley with an average height

of 40 feet and a maximum height of 85 feet. If the water were conducted by a canal a distance of about a mile to the lowlands adjacent to St. Croix River, turbines could be installed with a head of 100 feet. This dam site is distant only 3 miles from other large, undeveloped powers on St. Croix and Yellow rivers, with which it could be easily and cheaply connected by electric transmission.

About half a mile below Clam Lake there is now a logging dam with a head of about 20 feet which raises the water in the lake 3 or 4 feet. This dam impounds the water from a drainage area of 283 square miles. United States engineers reported that a dam would need to be 560 feet long at this point to produce a head of 25 feet. Such a dam would have a capacity of 4,670,786,000 cubic feet,[1] and if properly regulated could be made to greatly increase the amount and value of the powers below. The engineers found that the bed of the river consisted of sand from 3 to 20 feet, at which depths, soundings indicated hard materials, supposed to be clay and gravel.

Another large water power is found at Clam Falls, in Sec. 13, T. 37 N., R. 16 W., where the river falls over a wide ledge of the "Keweenawan" rocks. A dam at this point impounds the drainage from an area of 45 square miles and develops a head of 34 feet. Between Clam Falls and Clam Lake the slope is small and the river valley is half a mile to 1.5 miles wide. The river profile is shown in the following table, compiled from surveys made by United States engineers.

Profile of Clam River from its mouth to Clam Falls.

Station.	Distance.		Elevation above sea level.	Descent between points.	
	From mouth.	Between points.		Total.	Per mile.
	Miles.	Miles.	Feet.	Feet.	Feet.
Mouth of river	0.0	.....	888	.....	.....
St. Croix, road crossing	6.0	6.0	881	13	2.2
Clam Lake, mouth	19.0	13.0	947	66	5.1
Sec. 35, T. 38 N., R. 16 W., south line	29.0	10.0	967	20	2.0
Clam Falls	32.5	3.5	.....	.....	.....

NAMEKAGON AND TOTOGATIC RIVERS.

Namekagon River rises in a large lake of the same name near the divide in the watersheds of Chippewa and Bad rivers. Its drainage area is second in extent of all the St. Croix tributaries. Namekagon Lake is formed by six or more connected lakes, occupying parts of 14

[1] Rept. Chief Eng. U. S. Army, 1880, p. 1619

sections and surrounded by extensive cedar and tamarack marshes. In the upper 60 miles of its course the river is generally narrow and swift, stretches of rapids over pre-Cambrian crystalline rock being frequent.[1] There are also several vertical falls of 2 to 4 feet, which together with the rapids, furnish good opportunities for water powers. The banks are high on either side, stretching away into high, broken ridges and sand barrens covered with timber. In the remaining 25 miles of its length the river is from 100 to 200 feet wide. In this reach it descends 130 feet, including several sharp pitches and rapids, the principal of which are Little and Big Bull rapids and Dupee flats. The average slope of the river is 5.3 feet per mile.

A good location for a dam is found 4 miles above the mouth of the river, where the high gravel banks approach within 600 feet. A head of 20 feet or more could be obtained here without overflowing much land, impounding the drainage from 1,000 square miles. With the ordinary low water flow estimated at one-third of a second-foot per square mile, this would produce 740 theoretical horsepower. Because of the storage effect of the present dams above this point, the river at this site might be made to produce nearly 1,000 horse-power. Another good location for a dam is found at Veazie, on the Chicago, St. Paul, Minneapolis and Omaha Railway. By overflowing 6,000 acres, mostly railroad and government land, a head of 30 feet could be obtained, according to United States engineers. A dam of 15 feet head would cause little overflow. Such a dam would have the run-off from about 800 square miles and at ordinary low water would produce 275 theoretical horsepower. Small dams are located at Stinnett and at the outlet of Lake Namekagon. A dam owned by the Hayward Electric Light and Power Company, located near Hayward, develops 200 horsepower and is used for light and power purposes in that city.

Additional information regarding undeveloped powers is given in the following profile:

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[1] Simar, V. B., Asst. U. S. Engineer: Rept. Chief Eng. U. S. Army, 1880, p. 1616.

Profile of Namekagon River from its mouth to Cable, Wis.[1]

No.	Station.	Distance.		Elevation above sea.	Descent between points.	
		From mouth.	Between points.		Total fall.	Per mile.
		Miles.	Miles.	Feet.	feet.	feet.
1	Mouth of river	0.0	.....	‡908.0	.....	.....
2	Sec. 33, T. 43 N., R. 14 W., east side	4.0	4.0	917.8	9.8	2.4
3	Totogatic River, mouth	5.0	1.0	918.0	.2	.2
4	McKinzie Creek, mouth, sec. 28, T. 42 N., R. 13 W	13.0	8.0	944.0	26.0	3.2
5	Stuntz Brook, mouth, sec. 27, T. 42 N., R. 13 W	15.0	2.0	852.0	8.0	4.0
6	NE. ¼ sec. 34, T. 41 N., R. 13 W.	16.0	1.0	958.0	6.0	6.0
7	NW. ¼ sec. 6, T. 40 N., R. 12 W.	19.5	3.5	990.0	32.0	9.0
8	Sec. 18, T. 40 N., R. 12 W., near center	21.5	2.0	1,004.5	14.5	7.2
9	Sec. 39, T. 40 N., R. 12 W., near center	24.0	2.5	1,024.2	19.7	7.9
10	SW. ¼ sec. 27, T. 40 N., R. 12 W.	25.5	1.5	1,025.2	1.0	0.7
11	Veazie, sec. 36, T. 40 N., R. 12	28.5	3.0	1,039.0	13.8	4.6
12	River Jordan, mouth, sec. 21, T. 40 N., R. 11 W	35.5	7.0	1,058.0	19.0	2.7
13	Spring Brook, mouth, sec. 15, T. 40 N., R. 11 W	37.0	1.5	1,068.0	10.0	6.6
14	Chippenacia Creek, mouth, sec. 33, T. 40 N., R. 10 W	43.0	6.0	1,115.0	47.0	7.8
15	Stinnett	45.0	12.0	1,136.0	21.0	10.5
16	Little Puckanance	59.0	14.0	1,218.0	82.0	5.9
17	Cable, Bayfield County	70.0	11.0	1,303.0	85.0	7.7

[1] Authority: Nos. 1-14, and 16, U. S. engineers; 15 and 17, Chicago, St. Paul, Minneapolis and Omaha Railway.

In its length of 55 miles, Totogatic River, the principal tributary of the Namekagon, descends 350 feet. It enters the main stream only 5 miles above its mouth. The region is high and precipitous, with frequent ledges of pre-Cambrian crystalline rock and bowlders. As a result, the stream forms for miles a series of rapids with many vertical falls of 10 feet or more. Many logging dams already exist, the most important being located as follows: Sec. 13, T. 42 N., R. 10 W.; sec. 6, T. 42 N., R. 10 W.; and sec. 12, T. 43 N., R. 10 W. A good site for a dam is near the outlet of Gilmore Lake, in Sec. 9, T. 42 N., R. 12 W.; and another in sec. 12, T. 42 N., R. 12 W. The following profile of Totogatic River is compiled from surveys made by United States engineers:

Profile of Totogatic River from its mouth to N E. ¼ sec. 15, T. 42 N., R. 9 W.

Station.	Distance.		Elevation above sea	Descent between points.	
	From mouth.	Between points.		Total.	Per mile.
	Miles.	Miles.	Feet.	Feet.	Feet.
Mouth of river	0.0	.....	918.0	.....	.....
Sec 13, T. 42 N., R. 13 W., dam	11.5	11.5	975.5	57.5	5.0
NE. ¼ sec. 10. T 42 N., R. 12 W	20 0	8.5	1,006 8	23.3	2.7
NE. ¼ sec. 3, T. 42 N., R. 10 W	37.0	17.0	1,168.4	159.6	9.4
NE. ¼ sec. 13, T. 42 N., R. 10 W	40.0	3.0	1,241.6	73.2	24.4
NE. ¼ sec. 15, T. 42 N., R. 9 W	50.0	10.0	1,251.6	10.0	1.0

MINOR STREAMS.

Osceola Creek.—Emptying into St. Croix River a few miles south of Willow River is a small stream known as Osceola Creek. In the city of Osceola, near its mouth, is a water power with a head of 90 feet, owned by the Osceola Mill and Elevator Company. This dam furnishes the power to run a mill with a capacity of 175 barrels per day. One-fourth of a mile above is another dam with a head of 26 feet.

Kinnikinnic River.—A small river emptying into St. Croix River only 5 miles above its mouth bears this name. Its gradient is so high that there are a number of good sites for water powers. The descent in 10 miles is 190 feet. The following is a tabulated statement of its water power:

Water powers on Kinnikinnic River.[1]

No.	Location.	Owner and use.	Head.	Estimated horse-power.	Remarks.
			Feet.		
1	3 miles from mouth	N. Kohl, flouring mill	10	70	Timber dam.
2	5 miles from mouth	.....	.....	.....	Good dam location.
3	7 miles from mouth	.....	20	.....	
	River Falls:				
4	3 miles below	.....	14	.....	
5	1 mile below	City waterworks	15	60	Timber dam, 9 by 120
6	River Falls:	do	39	140	Timber dam.
7	do	Geo. Fortune, mill and elevator	8	40	Timber dam, 4 by 210
8	do	Prairie mill and elevator	14	60	Timber dam, 12 by 180.
9	7 miles above River Falls.	Clapp's mill	10	.....	Dam out.
10	South Branch, sec. 1, T. 27 N., R. 19 W.	W. H. Putnam, feed and flour	50	30	Timber dam, 26 by 114.
11	1 mile above No. 10	Glass Bros', manufacturers.	14	....	
12	Balsom Lake	J. W. Park, lumber and flour	.....	180	

[1] Figures are low-water estimates. Nos. 1 and 5-12 developed; 2-4, undeveloped.

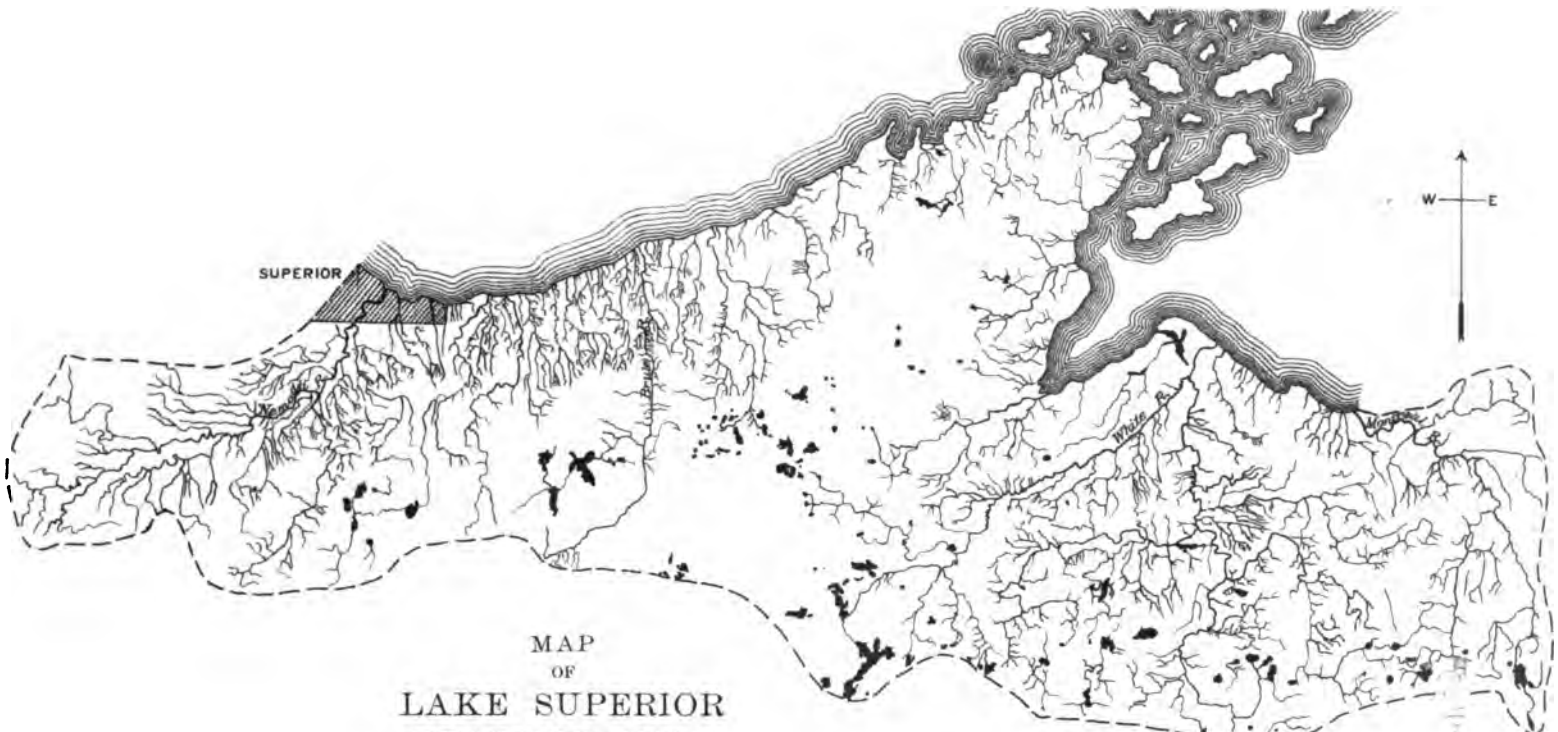
LAKE SUPERIOR DRAINAGE SYSTEM.

TOPOGRAPHY.

The watershed which limits the area of Lake Superior drainage in Wisconsin varies in elevation (above the level of Lake Superior) from 600 feet near the Minnesota line to over 1,000 feet near the Michigan line. Its average distance from Lake Superior is only 30 miles. For this reason the rivers are comparatively small; but owing to the fact that their large fall of 600 to 1,000 feet, is largely concentrated at a few points they offer many opportunities for water-power development. From a point near the center of the watershed a wide and nearly flat table-land, of which Bayfield Peninsula and the Apostle Islands form the northern prolongation, separates the drainage into eastern and western sections of nearly equal area. In both of these sections three distinct belts of topography are usually distinguished. The southernmost belt consists of a plateau in large part covered with swamps and lakes and is so flat that in many cases the water from the same swamps and lakes may flow either north to Lake Superior or south to the Mississippi.

From this flat watershed the descent northward is gradual until a range of mountains from 600 to 900 feet above the level of Lake Superior is reached. The northern slope of these mountains is much steeper than their southern slope, forming a marked though not continuous escarpment.

In the western section these mountains, known as Douglas Copper Range, reach a height of 400 to 600 feet above the lake and have a width of 1 to 4 miles. They extend in an east-northe[illegible] direction, gradually merging into the Bayfield moraine. From the crest of the mountains there is a sudden descent of 300 to 400 feet, caused by a faulting of the rocks. The Lake Superior rivers break through the



MAP
OF
LAKE SUPERIOR
DRAINAGE AREA
1907
SCALE
0 5 10 15 20 25 MILES
WISCONSIN

ridges at this point, and here the greatest opportunities for water-power development are to be found.

In the eastern section the mountains, called the Penokee Iron Range, extend from a point on the Michigan boundary, 12 miles from Lake Superior, in a southwesterly direction for about 35 miles, gradually merging into the plateau. As in the western section, many falls and rapids occur in breaking through the hard "Huronian" rocks of which the range is composed. Smaller falls continue for a distance of 5 to 6 miles after crossing the Penokee Range, or until the Copper Range has been crossed.

To the north of the highlands and extending with a gradual slope northward to the shores of Lake Superior lies a plain with a width of 5 to 15 miles. Its northern portion reaches an elevation of 100 to 200 feet above Lake Superior or 700 to 800 feet above the sea. The entire belt is underlain by till and deep layers of red clays sometimes mixed with sand. The rivers, both large and small, have cut deep and narrow banks in the clay soil. As a result the surface is carved in every direction by narrow water courses whose steep sides have a height of 25 to 100 feet, making railroad and highway construction expensive. Very few swamps are found in this lowland area. Because of the gradual slope of the shallow rivers opportunities for water-power development in this belt are rare. In many cases, however, there are important falls at the immediate mouths of the rivers and over the red sandstone.

Water Powers.

GENERAL STATEMENT.

Owing to the fact that the rivers of the Lake Superior system in Wisconsin have a total fall of 400 to 1,000 feet in the narrow belt of 30 miles separating the plateau region in which they rise from Lake Superior, their currents are characteristically rapid. As a result the rainfall is quickly discharged, the streams alternating between small creeks and torrential rivers. While the storage of surplus waters is important everywhere in the State for the economical development of water power, it is here doubly so. The fact that the most important falls and rapids are in the upper half of the drainage area increases the difficulty of storing a large proportion of the rainfall. With a

storage of less than 5 to 15 per cent of the rainfall most of the rivers would furnish at low water an insignificant flow.

Rainfall data regarding this drainage area are scanty, but sufficient to show that the rainfall increases from the lake to the highlands. This fact is strikingly shown by the precipitation map published by the United States Weather Bureau. It is here seen that the rainfall increases southward at the average rate of about 5 inches every 25 miles, the maximum not being reached until after the highlands are passed. That fact has an important bearing on the value of the water powers, because, as already stated, it suggests the location of reservoirs to a large extent in this region of greatest rainfall. The most important water powers occur near the Copper ranges and the Penokee Iron Range, where future mining operations may render them of much economic importance.

ST. LOUIS RIVER.

Although the water powers of St. Louis River lie outside the State, they are located so near the Wisconsin boundary that development

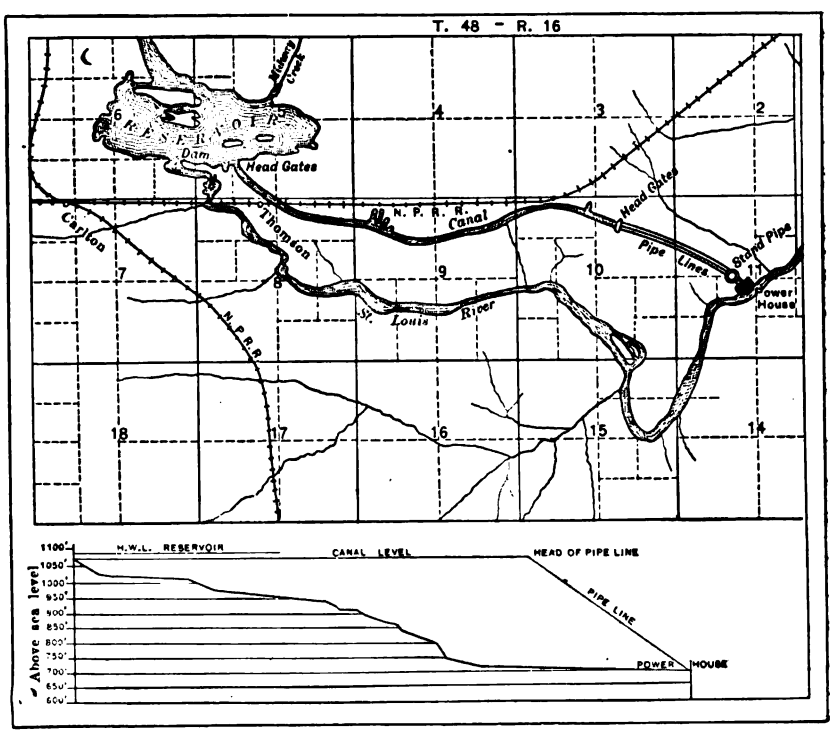
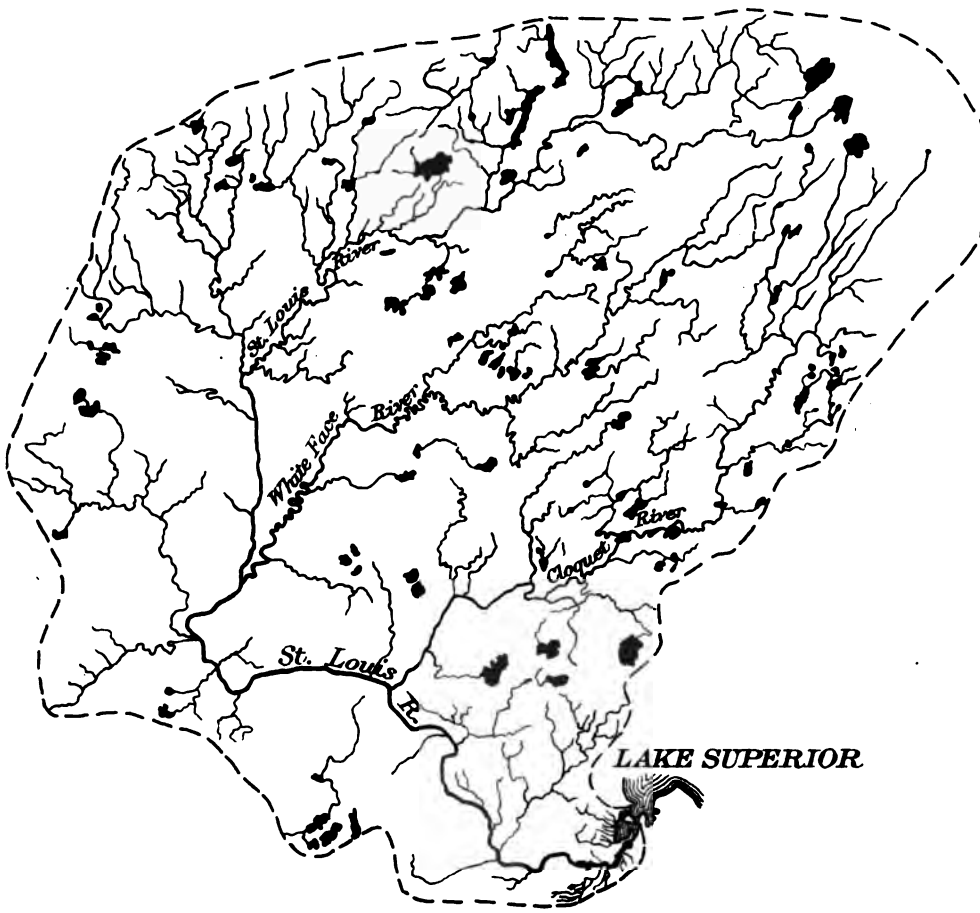


Fig. 14.—Plan of canal of Great Northern Power Company on St. Louis River.



MAP
OF
DRAINAGE AREA
OF
ST. LOUIS RIVER

SCALE 1" = 18 MILES

0 9 18 27 36 MILES

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RAPIDS AND DAM OF THE GREAT NORTHERN POWER CO.'S, NEAR SUPERIOR, WIS.
365 feet head, now developed.

contemplates their extensive use in Superior and other Wisconsin cities. An important feature of St. Louis River is the concentration of its descent in the lower reaches, where its volume is greatest. This provides opportunities for water power, which, if distributed among its smaller tributaries would be in large part wasted. The upper portions of St. Louis River are sluggish, flowing through many lakes and swamps, but as the waters near the lake their speed is increased until at a point about 22 miles from Lake Superior, just above Fond du Lac, there is a series of falls and rapids extending 6 miles upstream from a point 2 miles from the Wisconsin boundary. In this distance of 6 miles the river descends 456 feet in a series of wild leaps over the upturned ledges of slate rock, forming a water power which has few superiors in the West. This power and the riparian rights are owned by the Great Northern Power Company.

The present practice in the design of hydro-electric plants of providing generating units and auxiliary apparatus of large capacity instead of the multiplication of smaller machines is well illustrated in the Great Northern Power Company's plant.

This water power plant, situated near Superior, Wisconsin, on the St. Louis River and now under construction, is second only to the great hydraulic plants at Niagara for, when fully completed, it will call for the generation of 200,000 h. p.

The initial equipment, now under way, is for 30,000 h. p., with an ultimate capacity at this station of 80,000 h. p. Power from this plant will be transmitted 14 miles to Duluth and Superior but, eventually, it is planned to transmit power 50 to 75 miles for the operation of the great Mesabi and Vermillion iron ranges.

The relative positions of the power house, dam reservoirs, etc., are shown in Figure 14. From the head gates to the power house is a distance of 2.8 miles, about two miles of which is canal and forebay. Over the remaining distance the water is carried through 3,800 feet of wood stave pipe and about 1,000 feet of seven-foot steel pipe for each water wheel unit of 10,000 horse power. The total head thus developed is 365 feet.

A complete account of the electrical installation may be found in the Electrical World of July 28th, 1906. A view of the dam at the head of the rapids and the rapids below is shown in Plate XLIV.

NEMADJI AND BLACK RIVERS.[1]

Unlike other rivers of the Lake Superior watershed, Nemadji River flows northeast instead of north and does not rise in an elevated region. As a result it is devoid of important rapids or falls suitable for water power.

Black River, the most important tributary of the Nemadji, rises in an elevated country, its source being in a lake on the Minnesota boundary. It flows north and empties into Nemadji River about 10 miles from Lake Superior at an elevation of only 20 feet above the lake. In the upper two-thirds of its length Black River flows through many tamarack and cedar swamps, which give to its waters a distinct color and taste. Up to about 4 miles from the Douglas Copper Range it occupies a wide valley with small descent. As this range is approached the valley narrows and its gradient increases. In the SE. ¼ Sec. 28, T. 47 N., R. 14 W. the hard layers of the "Keweenawan" rocks cross the river, producing a vertical fall of 31 feet. A total head of 160 feet[2] could easily be obtained here for a dam site. A view of these falls is shown in Plate XLVI. As Black River has a drainage area of 80 square miles above these falls, an assumed run-off of 0.4 second-foot per square mile gives 560 theoretical horsepower. A company was formed some time ago to improve this power, and a franchise was secured from the city of Superior for lighting by electricity, but no construction has yet been done. The water at the head of the upper rapids is 387 feet above Lake Superior; at their foot, 50 yards beyond, the elevation is 227 feet. From this point the river passes for nearly a mile through a gorge 100 to 170 feet deep, below which the walls of the gorge are less elevated above the stream, but the current is very rapid until it joins Nemadji River 4 miles below. From the foot of Black River Falls to the junction with the Nemadji the total descent is 200 feet, an average of 50 feet to the mile.

BOIS BRULE RIVER.

Though over 33 miles long, Bois Brule River has a drainage area of only 200 square miles, practically all of which is in the highland district. It rises in a swamp, near St. Croix Lake, at an elevation of

[1] The authority for most of the statements concerning the Lake Superior rivers is Prof. R. D. Irving: Geology of Wisconsin, vol. 3, 1880.

[2] Sweet, E. T., Geol. Wisconsin, vol. 3, 1880, p. 319.

FALLS OF THE BLACK RIVER, SE. ¼ Sec. 28, T. 47 N., R. 14 W.
Total fall 160 feet.

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420 feet above the level of Lake Superior. In Sec. 15, T. 46 N., R. 10 W., at the Dalles, Bois Brule River is only 25 feet wide, with banks of clay and bowlders averaging 8 feet in height. Near this point there are swift rapids, with a total descent of about 15 feet in 200 yards. Similar rapids about 3 miles farther north, near the township line, continue as far as the mouth of Nebagemain River, the most important tributary of the Bois Brule, in Sec. 27, T. 47 N., R. 10 W. For the next 10 or 12 miles the current is very sluggish until the head of the lower rapids is reached, in Sec. 26, T. 48 N., R. 10 W. From this point to within 1.5 miles of Lake Superior rapids and small falls (the largest being 4 or 5 feet in height) occur almost continuously. These descend an aggregate of 200 feet over "Keweenawan" eruptives and sandstones. By constructing dams at the outlets of Lakes Nebagemain and Minnesung the surplus water could be held back and used at times of low water, thus adding greatly to the value of the water powers on the river. At present there are no dams. Mr. Howard Thomas, city engineer of Superior, Wis., states that the normal discharge of this river is 100 second-feet and that at several points heads of 40 feet could be obtained by dams between bluffs or with dams and flumes along the banks. Such a head would give 450 theoretical horsepower. Because of its comparatively small watershed and the fact that the river is fed very largely by springs it is not subject to freshets.

MONTREAL AND GOGOSHUNGUN RIVERS.

For nearly its entire length Montreal River forms a part of the Michigan-Wisconsin boundary. It rises in a tangle of lakes and tamarack swamps near the boundary line at an elevation of about 1,600 feet above sea level, or 1,000 feet above Lake Superior. Its length is 50 miles, the highest gradient being concentrated in the last quarter of this distance. This exception to the general rule of the Lake Superior drainage area is due to the fact that here the Penokee Iron Range and its associated highlands of the "Keweenawan" series approach Lake Superior within a distance of only 3 miles, leaving no lowland region.

About 1,300 feet from its mouth, on the north line of Sec. 7, T. 47 N., R. 1 E., is a vertical fall of 35 feet over sandstone. It is stated by an officer of the Duluth, South Shore and Atlantic Railway that a head of 55 feet could be developed here by constructing a flume

100 feet long. Because of the lakes and swamps at the headwaters of this river it is likely that at least 5 per cent of the annual rainfall could be stored in reservoirs. This would give, from its 280 square miles of drainage area, an ordinary flow of 140 second-feet, equivalent, with a head of 55 feet, to 868 theoretical horsepower. In the last five-eighths of a mile of its course Montreal River descends 90 feet. The railway official mentioned above also states that another power site is located in the NW. ¼ SW. ¼ Sec. 21, T. 47 N., R. 1 E., at falls of 60 feet over the crystalline rocks. As the banks are high, a 20-foot dam, with a flume 250 feet long, would develop a head of 80 feet. Both of the above powers are within 4 miles of the Duluth, South Shore and Atlantic Railway. At Ironwood, about 2 miles above these falls, the river has an elevation of 880 feet. In the 5 miles above Ironwood the river descends only 30 feet, and for the remainder of its upper reaches its current is slow. At all the rapids on this river the conditions are favorable for the building of dams.

Under date of April 9, 1907, Edward P. Burch, consulting engineer, writes that his surveys of Montreal River near Saxton Falls showed that a dam with 120 foot head was feasible. His measurements of the discharge of Montreal River during the winter of 1906 and 7 showed a minimum flow of 102 cubic feet per second. Survey for reservoirs on headwaters of this river have also been made which show that a system of reservoirs can be constructed at moderate cost.

The Gogoshungun, a branch of the Montreal, is nearly as large as the upper Montreal, being about 30 miles long. Its total descent is 500 feet. Until the river reaches the Penokee Range its current is sluggish, being bordered by swamps. In its passage through the mountains, in Sec. 27, T. 46 N., R. 2 E., a number of rapids and falls occur.

BAD RIVER.

MAIN RIVER.

The sources of Bad River lie in large swamps 8 miles south of the Penokee Iron Range, at an elevation of 900 feet above the level of Lake Superior. In this distance of 8 miles its descent is 110 feet, but its course is sinuous, as may be inferred from the fact that the Wisconsin Central Railway is forced to cross it eight times. About 1½ miles above Mellen are rapids called Copper Falls, which have a total descent of about 60 feet (Pl. XLVII.) The river at this point has

Fig. 1. COPPER FALLS, BAD RIVER.
SE. ¼ Sec. 17, T. 45 N., R. 2 W. Ashland Co., Wis.

Fig. 2. LOWER FALLS OF AMINICON RIVER, Sec. 29, T. 48 N., R. 12 W.

a drainage area of about 144 square miles. According to a survey, 5 per cent of the annual rainfall could be easily stored in dams near the headwaters, which should provide an ordinary flow of 68 second-feet, equivalent to 460 theoretical horsepower.

"Near the Penokee Range Bad River enters a gorge of pinkish granites, narrowing in places to a width of 10 feet and descending 20 feet in 30 rods, with a total descent of 50 feet in three-fourths of a mile. The river then widens and continues with reduced grade until Penokee Gap is reached, when it again contracts. Coming into contact with the "Huronian" rocks, it flows along their strike. In the next four miles occur many rapids and several falls, including one of 35 feet." In the next 1,000 feet, in which the river descends 40 feet, Tylers Fork, the most important tributary, is reached. Directly at the junction Tylers Fork has a fall of 45 feet over the wall of a gorge 65 feet deep. This is in Sec. 17, T. 45 N., R. 2 W. A competent engineer, reporting on this water power, states that dams could develop here a head of about 120 feet. This tributary drainage area is given at 234 square miles. On the assumption that the rainfall is only 32 inches and that reservoirs can be made to store 15 per cent of the rainfall, it was estimated that the river would furnish a continuous flow of 206 second-feet, equivalent to about 3,000 theoretical horsepower. It was proposed to conduct this power electrically to Ashland. See Plate XLVIII for view of falls.

In the next 1,000 feet below Tylers Fork the river flows through a rocky gorge 100 feet deep, beyond which the rocks disappear and the stream flows between high banks of red clay, the ground rising rapidly on both sides. The total descent in Sec. 17 is probably 135 feet. In the next 6 miles of its sinuous course, to the mouth of Maringouin River, the river descends about 30 feet to the mile. Both rivers at their confluence are broad and deep, with slow-moving, muddy currents and wide bottom lands—conditions which continue to the mouth of Bad River.

Farther north, 2¼ miles from this junction, Bad River receives the waters of Potato River. At this point its elevation is 80 feet above the level of Lake Superior. In Sec. 25, T. 47 N., R. 3 W., occur some small falls, of 1 or 2 feet, over red sandstone and shale, which continue for perhaps 2 miles. Below these falls Bad River continues sluggish, deep, and tortuous, with bold and high clay banks, until White River is reached. For the remainder of its course the river finds its way to Lake Superior through swamps.

TRIBUTARIES.

The principal tributaries of Bad River, named in order from its mouth, are as follows: White River entering from the west; Potato River from the east; Maringouin or Mosquito River from the west, and Tylers Fork from the east.

White River.—This river, the largest tributary of Bad River, has a total length of about 45 miles, and drains an area of 400 square miles. It rises in Long Lake, at about 700 feet above the level of Lake Superior. Most of its descent is concentrated in its upper waters, where its discharge is least. It pursues a general northeasterly course with many windings through high and steep clay banks, like those described on Bad River. Its only considerable falls are in Sec. 6, T. 46 N., R. 4 W., where the river was originally obstructed by the edges of southward-dipping rocks. A dam with a 20-foot head has been maintained here for several years, and until October, 1903, furnished the power to run a paper mill. At that time the mill burned. The White River Power Company, of Rhinelander, Wisconsin, is now, November, 1906, engaged in further developing this same power. A concrete dam carrying a head of 32 feet is being built in Sec. 6, T. 46, R. 4 W. and it is planned to have the contract completed and the machinery in operation by September, 1907. The water will be carried by a 9 foot pipe from the dam to a point 1,400 feet lower down stream. The turbine installation will consist of 2 pair of twin wheels each unit capable of developing 900 H. P. and directly connected to 500 K. W. generators. The current will be transmitted to Ashland and leased for power and lighting purposes. The owners estimate a minimum power of 1,000 H. P. The officers of the company are A. W. Shelton, President; C. A. Wixson, Secretary, and E. A. Edmonds, Treasurer.

Maringouin River.—Maringouin River, sometimes also called Maringo (Mosquito) River, has a total length of about 40 miles and drains an area of 231 square miles. Four miles from its source it crosses the Penokee Range. Here, in the NW. ¼ Sec. 23, T. 44 N., R. 5 W., the river descends, in a series of three falls, a total distance of 65 feet within a few rods. The two upper falls, of 15 and 25 feet, respectively, are only 50 feet apart. Nothing but the limited amount of water prevents this from being a valuable water power. For the remainder of its course the river is devoid of falls or rapids flowing between high clay banks.

TYLERS FORKS FALL, SE. ¼ Sec. 30, T. 44 N., R. 2 W.
Fall, 45 feet.

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VIEW OF FALLS AT JUNCTION OF BAD RIVER AND TYLER'S FORKS.
Sec. 17, T. 45 N., R. 2 W.

Within 6 miles of its junction with Red River, the Maringouin receives several rapid tributaries, the most important of which is Brunsweiler Creek. This creek rises in the same swamp with Maringouin River, but, unlike it, has important falls north of the "Huronian" hills. Until Bladder Lake is passed in Sec. 11, T. 44 N., R. 4 W., the current is sluggish. The outlet of this lake is only 6 feet wide, with rock walls on either side. A dam which would greatly raise the water in the lake could be constructed here at slight expense. At the outlet of the lake there is a long series of chutes and rapids for a distance of over 6 miles. In this stretch the creek flows through a narrow valley with steep, rocky hills. The last important descent occurs near the north line of Sec. 22, T. 45 N., R. 4 E., where the stream leaves the Copper Range, the slope being 30 feet in a distance of 130 feet.

Tylers Fork.—This tributary is the only one which joins Bad River before the lowlands are reached. Tylers Fork, nevertheless, has a length of 30 miles and a total descent of 700 feet. Until it reaches the Penokee Range its current is sluggish. In the NE. ¼ Sec. 33 T. 45 N., R. 1 W., the river falls 20 feet over the hard "Huronian" rock. Less than a mile farther on, in Sec. 28, occurs a series of low falls over black slate, the descent being 20 feet in a distance of 500 feet. On the north line of sec. 20 the river surface is 760 feet above the level of Lake Superior. In the next 10 miles of its course it descends 260 feet, but without any considerable rapids. On the west line of Sec. 15, T. 45 N., R. 2 W., the elevation of the water is 485 feet. The current now becomes swifter and about a quarter of a mile below the east line of Sec. 16 is a series of rapids which continues to its junction with Bad River; ending in the 45-foot fall shown in Plate XLVIII. As these falls and rapids are within a mile of the Wisconsin Central Railway, they seem destined to become of some economic importance.

Potato River.—In its course of only 30 miles, Potato River has a descent of over 900 feet. The river is small until it is joined in Sec. 15, T. 46 N., R. 1 W., by Little Potato River. From this confluence a course nearly due west for 12 miles takes it to Bad River. Near the east line of Sec. 17, T. 46 N., R. 1 W., at 428 feet above the level of Lake Superior, is a series of rapids followed by a series of cataracts. These rapids begin on the east line SE. ¼ SW. ¼ Sec. 17, T. 46 N., R. 1 W., and are in the trap rock. In the next quarter mile abrupt descents of 10, 4, and 40 feet occur, with swift water between.

A still larger fall of 60 feet or more is located near the west line of Sec. 17, and as the banks are high and precipitous, a suitable dam would develop a head of nearly or quite 100 feet. On both sides of the west line of Sec. 17, about 2,000 feet north of the southwest corner, is a series of bold falls having a total descent of 80 feet in a distance of 500 feet, with two leaps of 25 feet and 32 feet respectively. The total fall in Secs. 17 and 18 is 170 feet. These falls, being over solid rock of conglomerate and sandstone, furnish ideal conditions for dams. Below Sec. 18 the river course is tortuous and slow.

MINOR RIVERS.

Aminicon, Middle, Poplar, and Iron rivers are small streams in Douglas County. They are all swift streams with many small falls, but are subject to great variations of flow, being insignificant at low water. A corporation known as the Iron River Water, Light and Power Company has recently constructed a dam 135 feet long, with a head of 32 feet, on Iron River, in Sec. 22, T. 47 N., R. 10 W., the intention being to install turbines of 1,000 horsepower, which will be transmitted to near-by towns.

RAILROADS.

All the falls which occur near the Penokee Range on Bad River and Tylers Fork are near the Wisconsin Central Railway. Montreal and White rivers are crossed by the Duluth, South Shore and Atlantic, the Chicago and Northwestern, and the Wisconsin Central railways. The western half of the Lake Superior watershed has good transportation facilities. Branches of the Great Northern Railway cross the valley of Black River and follow the valley of Nemadji River. Besides these the drainage is crossed by the Northern Pacific, the Chicago, St. Paul, Minneapolis and Omaha, and the Minneapolis, St. Paul, and Sault Ste. Marie railways, and by minor logging roads.

PART II.

WATER POWERS OF SOUTHERN WISCONSIN.

PRESENT CONDITIONS.

It is perfectly manifest that water powers can be of only potential economic importance until the region in which they are situated becomes populated and developed.

The building of cities and the clearing up of farms is followed in turn by the creation of railroads and other means of transportation. These changes combine to create a demand for power, while the railroads provide means for both getting in the raw materials for use in manufacture, and also for delivering to distant buyers the manufactured products.

The water powers of southern Wisconsin are noteworthy for their wide and uniform distribution rather than for their great size.

The only large river in this region is the Wisconsin and even this has so moderate a fall and so wide a valley as to afford only two opportunities for development. The shorter rivers with few exceptions have fairly rapid fall, which compensates for their lack in volume.

But while the settlement and cultivation of this region have called into use the many water powers on these streams, the same cultivation has resulted in appreciably lessening these same powers.

The number of mills which have been burned down or allowed to stand idle and decay during the past decade furnish abundant proof of this condition. A brief statement of the most important elements contributing to this condition is not without interest.

1. The clearing of the forests and the general draining of many swamps and marshes which formerly conserved the water have allowed the storm water to reach the rivers in much shorter time. This has resulted in greatly increasing the size of the freshets and in correspondingly decreasing the low water flow in the rivers.

The freshets have largely increased the difficulty and expense of keeping the dams in repair. The decrease in the low water flow has

caused the installation of many steam plants to supplement the water power during the period of low water. This duplication of power plants has been a potent cause for the neglect of the water powers.

2. The cultivation of the valley lands has resulted in the freshets carrying increasingly larger amounts of silt into the rivers, which in the course of many years settle in the ponds, thereby seriously decreasing the pondage.

3. Again many of the dams were built and originally used for sawing lumber. With the clearing away of the forest such of these dams as could not be diverted to other purposes were necessarily abandoned and allowed to decay.

4. Before the great milling industries of Minneapolis and other cities became so developed as to furnish the present large proportion of flour for this and other states, many dams were used to grind the flour products needed by the people of their neighborhood, but at present these small industries find it increasingly difficult to compete with the great corporations mentioned above.

5. Another cause for the decline of the smaller water powers has come from rapid appreciation in value of the neighboring farm lands. In many cases the value of the flooded lands, for agricultural purposes, was greatly in excess of the value of the water power. This condition has naturally resulted in the purchase of many dams by the adjacent riparian owners followed by the destruction of the dam and the addition of its overflowed lands to the holdings of the farmers. But it must not be understood that all the many changes incidental to the development of the state have resulted alone in the detriment of the water power. With the waning of lumber and flouring interests mentioned above, has come the development of many new and varied manufactures all requiring power, while the decrease in freight rates has certainly contributed largely to their establishment.

Probably the most important users of water power of recent installation, are the paper and woolen mills and the electric light and traction companies. The increased possibilities of water power due to the use of electric transmission are difficult to overestimate. This improvement renders it possible to generate power at a distant point where power is found in great quantities and transmit it to other localities where transportation or other facilities render it more valuable. A good example of this fact is seen in the proposed development of about 10,000 horsepower at the little town of Kilbourn on

the Wisconsin River and its distribution in Madison fifty miles distant as well as to the smaller cities between, now under construction.

The cheaper generation of water power should result in the general supply of the electric light and power at a much cheaper rate than that which comes from steam dependent upon distant coal mines. In this connection it must not be overlooked that the tendency of the price of the coal is always to rise, due both to the increase in miners' wages and the increasing difficulty of mining the coal.

In order that the people, and not alone a few corporations, may profit by the cheapness of water power it is necessary that the charters granted to such corporations shall carefully guard the interests of the entire people. It is to be regretted that this has not always been done in the past.

A second way in which the improvements of electric transmission of power is manifest is seen in the joining by wire of a number of relatively small powers on the same or adjacent rivers and the transmission of the combined power to the same central plant, where it can be used to greatest profit and economic advantage. In this way a number of relatively insignificant powers can be combined to produce a valuable power. A good example for such a combination is found on Cedar Creek above Mayfield.

UNDERGROUND WATERS.[1]

The source of water supply for the crystalline region, with the exception of some of the sandstones of the Keweenawan epoch and softer horizons of the Huronian, is restricted chiefly to the overlying bed of drift. This area as a whole has a very poorly developed drainage. The water table in most cases lies near the surface. Deep wells are seldom needed in this sparsely settled region. Cool, soft, and comparatively pure water may easily be obtained from the numerous springs, small streams, ponds, rivers, and lakes.

"*Potsdam Sandstone.*—The greatest of the rock water horizons of this area, and the one that universally furnishes a large supply of water, is the Potsdam sandstone, which nearly surrounds the crystalline rocks. To the south and east this formation is the great source of the artesian waters found scattered over the district. On the north a few records show that waters from its beds rise considerably above the level of Lake Superior. The impervious interbedded shales of

[1] See bulletin 114, U. S. Geological Survey, page 283.

the formation furnish ideal conditions for a good artesian supply at many places within the outcrop area itself. The shales, though not every where present, often gives rise to several separate horizons of water-bearing rock. Wells of this nature may be found at Sparta, Whitehall, Durand, and numerous other places in Wisconsin. Although the water from this formation does not reach the surface in many places, owing to the topography, it is always abundant, and may be depended upon as a supply for city purposes. On account of the advanced erosion and deep-cut valleys the entire Potsdam area west of Green Bay and north of Wisconsin River does not obtain any artesian water from beyond its own limits. Although water is abundant everywhere the artesian flows of this area are confined to the Mississippi Valley and its deeply eroded tributaries—St. Croix, Chippewa, Trempealeau, La Crosse, Wisconsin, Kickapoo, and Baraboo rivers—while on the east this artesian basin extends to Lake Michigan, and on the south it passes under the Carboniferous deposits. Whether artesian flows may be obtained depends largely upon the elevation above sea level.

Lower Magnesian Limestone.—Along the eastern margin several water horizons are found above the Potsdam sandstone. Usually a sufficient supply for domestic use is obtained from the Lower Magnesian limestone, 50 to 100 feet from its top. In a few places this formation gives rise to flowing wells, which in some cases are caused by water from the Potsdam sandstone filling the cracks and fissures of the Lower Magnesian.

St. Peter Sandstone.—The second greatest horizon of the area is the St. Peter sandstone. Although of less importance than the Potsdam, it furnishes an abundant supply of good water in the eastern and southeastern portions of the district. Northward it becomes of less importance, as it thins out and in many places pinches out entirely. In the southwestern part of the district artesian wells have generally not been obtained as the rivers cut through well into this formation. However, in these parts the St. Peter sandstone always gives an abundant supply of water for domestic uses.

Galena-Trenton Limestone.—The Galena-Trenton limestone, like the Lower Magnesian limestone, yields, in most cases, sufficient water for domestic use. It is seldom necessary to sink the wells more than 100 or 150 feet, and in some cases a sufficient supply for small cities has been obtained at 75 feet. In some localities, notably north of Green Bay, this formation gives rise to flowing wells. In some cases

it appears that the water of this formation is obtained from the underlying St. Peter sandstone, the overlying Niagara limestone, etc.

Niagara Limestone.—The Niagara limestone, although hard, compact, and in places highly impervious, furnishes a copious supply. Water is usually obtained from fissures, joint planes, or crevices at a depth considerably less than 200 feet. The formation furnishes requisite artesian conditions, and in a great many instances, particularly along the eastern half of its extent, between Manitowoc and Milwaukee, many fine flows are obtained.

Along the eastern margin of the district the artesian flows are confined to the vicinity of Lake Michigan and to a strip on each side of all the valleys. In the Green Bay and Rock River basins are many of the flowing wells of the interior. The rapid weathering of the impervious Cincinnati shale has reduced this part of the area to such a level that artesian waters might rise to the surface.

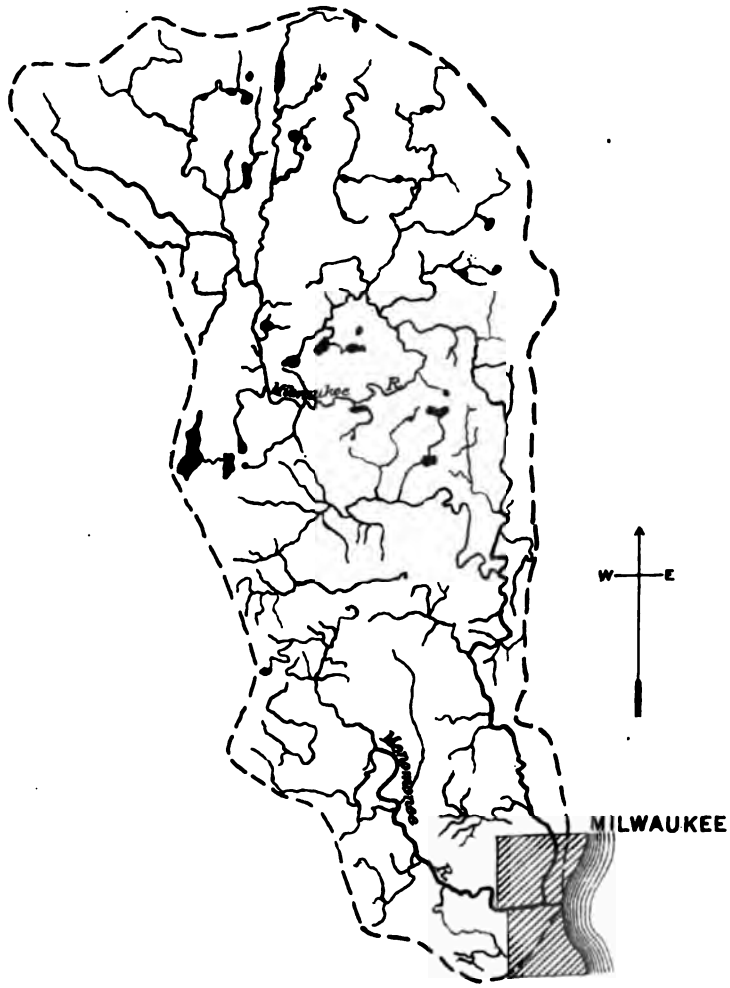
Lake Deposits.—Besides these deeper-seated waters and the waters coming from the lacustrine deposits along the shores of Lake Michigan and Lake Superior, the area is well supplied with shallow underground waters, commonly known as surface water. Surface wells are found by the score all over the drift area and vary in depths from 10 to 80 feet, and in some case, as along the Kettle Range in eastern Wisconsin, reach a depth of 300 to 400 feet. Many of these wells are not free from contamination, and during the last few years many have gone dry. In 1903, however, nearly all the wells formerly dry had a good supply of water. Along some of the larger streams water is obtained from the river-washed sand and gravel by sinking wells from 10 to 40 feet. Many of these are open or drive wells.

Springs.

Along both sides of the Kettle moraine glacial drift is the source of many fine surface springs and also of subterranean springs that feed so many of the small lakes. Other strong springs from the drift are scattered over the district. In the northwestern part of the area these strong springs flow from the drift overlying the trap rock and in many cases the water gushes forth in a small stream several feet wide and over a foot deep. So strong are some of these that they have been utilized for water power, as at St. Croix Falls, where a 35-horse power mill is operated by the water from a spring. Springs have their source in the upper surface of the Cincinnati shale along the east

ridge of the Green Bay and Rock River valleys or along the contact of the Niagara limestone and the Cincinnati shale. The impervious shale stops the descending waters flowing through the fissured Niagara limestone, and it escapes at the first opportunity, producing innumerable springs, both great and small, along the entire extent of this marked and important contact. Much of the water from this source never comes to the surface near the contact but flows underground through the sand and gravel beneath the red clay and gives rise to some of the fountains found east of Fond du Lac. The other important horizons are confined chiefly to the contact of the Potsdam sandstone and Lower Magnesian limestone and to the contact of the Galena-Trenton limestone and the St. Peter sandstone. In many cases in western Wisconsin springs also arise from various horizons of the Potsdam sandstone.[1]

[1] Bulletin 114, U. S. Geological Survey, pp. 237 to 240.



MAP
OF
DRAINAGE AREA
OF
MILWAUKEE RIVER

SCALE 1" = 10 MILES

0 5 10 15 20 25 MILES

MILWAUKEE RIVER.

Topography and Drainage.

The Milwaukee river rises in the glacial moraine known as the Kettle Range at a point only eight miles distant from the southern end of Lake Winnebago. After a course of 100 miles in a southern direction, it empties into Lake Michigan at Milwaukee. The last 35 miles of its length the river closely parallels the shore of Lake Michigan and at a distance of only one to four miles from it. The total area drained by the river is about 840 square miles. The following table gives a profile of the river.

Profile of Milwaukee River.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth at Milwaukee	0.0	.....	581.3	.....	.....
2	North Ave. Dam, Milwaukee, foot	3.0	3.0	581.8	0.5	.15
3	North Ave. Dam, Milwaukee, crest	3,0	0.0	595.8	14.0	.....
4	Burleight St., Milwaukee	4.0	1.0	600.0	4.2	4.2
5	Silver Spring Dam, foot	10.0	6.0	820.0	20.0	3.3
6	Silver Spring Dam, crest	10.0	0.0	623.0	3.0	.....
7	Dam No. 3, foot	11.0	1.0	623.5	0.5	0.5
8	Dam No. 3, crest	11.0	0.0	629.5	6.0	.....
9	W. ¼ stake Sec. 7, T. 8 N., R. 22 E.	13.5	2.5	640.0	10.5	4.1
10	Thiensville Dam, foot	18.5	5.0	647.2	7.2	.....
11	Thiensville Dam, crest	18.5	0.0	653.1	5.9	.....
12	S. E. ¼ Sec. 1, T. 9, R. 21, E.	23.0	4.5	660.0	6.9	1.5
13	½ mile S. of mouth of Cedar creek	25.0	2.0	680.0	20.0	10.0
14	Stone Quarry Dam, foot	28.0	3.0	693.2	13.2	.....
15	Stone Quarry Dam, crest	28.0	.....	702.2	9.0	.....
16	Woolen Mill Dam, foot	28.4	0.4	704.7	2.5	6.0
17	Woolen Mill Dam, crest	28.4	.....	715.7	4.0	.....
18	Grafton Flour Mill Dam, foot	28.6	0.2	718.7	3.0	.....
19	Grafton Flour Mill Dam, crest	28.6	.....	732.0	13.3	.....

Profile of Milwaukee River—Continued.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
20	Saukville	33.7	5.1	744.8	12.8	2.6
21	Site of old Saukville dam	34.4	0.7	747.2	2.4	3.5
22	C., M. & St. Bridgen, of Saukville	36.7	2.3	751.0	3.8	1.7
23	N. Unc. Sec. 34, T, N., R. 21 E.	41.0	4.3	773.4	22.4	5.2
24	Fredonia dam, foot	42.4	1.4	776.0	2.6	1.9
25	Fredonia dam, crest	42.4	.....	781.2	5.2	.....
26	N. E. ¼ S. E. ¼ Sec. 6. T. 11, R. 21 E.	48.5	6.1	820.0	38.8	6.3
27	Newberg dam, foot	50.5	2.0	834.9	14.9	7.5
28	Newberg dam, crest	50.5	.....	841.3	6.4	.....
29	Myra	54.5	4.0	855.2	13.9	3.5
30	N. E. ¼ S. E. ½ Sec. 18, T. 11 N., R. 20 E.	58.5	4.0	860.0	4.8	1.2
31	1 mile east of West Bend dam, foot of	60.5	2.0	876.0	16.0	8.0
32	1 mile east of West Bend dam, crest	60.5	0.0	883.0	7.0	.....
33	C. & N. W. Ry. crossing, West Bend	61.5	1.0	883.3	0.3	0.3
34	West Bend Dam, foot	62.0	0.5	890.2	6.9	13.8
35	West Bend Dam, crest	62.0	0.0	901.6	11.4	.....
36	Barton Dam, foot	63.5	1.5	902.0	0.4	0.03
37	Barton Dam, crest	63.5	0.0	913.2	11.2	.....
38	C., N. W. Ry Bridge	64.1	0.6	913.2	0.0	0.0
39	Highway Bridge 2 miles south of Kewaskum	68.5	4.4	921.6	8.4	1.9
40	Kewaskum Dam, foot	70.5	2.0	941.5	19.9	10.0
41	Kewaskum Dam, crest	70.5	0.0	950.1	8.6	.....
42	Ry. Bridge 4 mi. north of Kewaskum	74.5	4.0	958.0	7.9	2.0
43	Ry. Bridge Sec. 22, T. 14 N., R. 18 E.	.....	.....	1,018.0	.....	.....

Authority: 4, 5, 9, 12, 18, 26, 30, U. S. G. S. Topographic maps. 42 and 43 C. & N. W. Ry. The remainder were determined by spirit levels run from railroad datum by L. S. Smith and Ray Owen.

Of the 370 feet fall between the crest of the Kewaskum dam and the mouth of the river only 122 feet are now developed. It will be seen from the following description that over 100 feet more could be cheaply developed by building nine new dams and raising six of the present dams.

The valley traversed by this river is underlaid by the Niagara limestone which crops out frequently in the bed of the river. The average fall of the river south of Kewaskum is 5.2 feet per mile quite uniformly distributed.

While the size of this river does not entitle it to be ranked among the large rivers of the state, its steep gradient, over 5 feet per mile and strategic location in so fertile and populous a region should make its many water powers of unusual value. The increasing difficulty which the owners of the water powers have experienced in maintaining their dams in times of flood, together with the exceptionally low price of steam coal, due to cheap water freights, have to a great extent neutralized the natural advantages stated above. A large proportion of the water powers are at present unused and many of the remaining dams are greatly in need of repair. The following detail description of the water powers was derived from an actual survey supplemented by a study of the United States Geological survey topographic maps of the river valley.

Water Powers.

Milwaukee.—The first dam is situated in the city of Milwaukee about three miles from the mouth of the river. It is a stone dam 432 feet long and 14 feet high. Thirty years ago it was used to run a mill but was purchased by the city of Milwaukee and is now used to store water for flushing a sewer and for boating and bathing. It backs the water about 1¼ miles.

North Milwaukee Dam.—The second dam is located about seven miles above the Milwaukee dam. It is a timber dam 180 feet long with stone abutments and foundation and formerly developed a head of about 4 feet. In March, 1905, a freshet washed out around this dam and it is reported that the property will be sold at sheriff's sale. Turbines of 45 horse-power are installed. Steam power is also used. The present owner is the Silver Spring Milling and Manufacturing Company. This mill backs the water up about one mile to the next dam.

The third is a timber dam, 200 feet long, in good condition. Sixty horse-power turbines under a six foot head are used to run a flour and grist mill. This head could not be increased. The owner is Steffen Pieron.

Thiensville Dam.—In the 7.5 miles between Thiensville and dam number 3 the river falls about 17 feet, none of which is improved. The topographic map of this stretch indicates that at least six feet of this fall could be improved at reasonable expense.

At Thiensville a timber dam 210 feet long, built in 1843 develops a head of 6.5 feet. Three 56 inch turbines develop about 100 horse-power, used to run a flour and grist mill owned by P. J. Kroehnke. By flooding about 200 acres an additional head of two feet could be developed. The dam is in excellent condition, but was washed out in 1886.

Six and one-half miles above Thiensville, Cedar Creek joins the main river from the west adding a drainage area of 100 square miles. Although the river falls about 35 feet in this length, good dam sites are lacking because of the uniform flatness of the country. A head of about 10 feet could be secured by a dam about 1,000 feet long on the east and west quarter line of Section 6, Township 9 North, Range 22 East, and possibly also just below the mouth of Cedar Creek.

GRAFTON POWERS.

In Sections 19 and 30, Township 10, North, Range 22 East in a distance of about 1.5 miles from Grafton southward there is a fall of about 40 feet between high banks. Of this fall 36 feet have been improved by these dams, the lowest of which is the:—

Milwaukee Falls Lime Company Dam.—This is a rock filled dam, 90 feet long, developing a head of 9 feet. It lacks about 2 feet of backing the water to the foot of the next dam above. The power is used to compress air for drilling in a near-by stone quarry and is owned by Edward Moellen, Grafton, Wisconsin. Formerly, this dam was two feet higher but the owners of the dam above compelled the owner to lower it 2 feet as a result of a lawsuit.

Sheboygan Knitting Company Dam.—The middle dam is located only 1,800 feet above the last described dam. It is a plank and stone dam, 140 feet long, developing a head of 12 feet. Only one 60 inch turbine has been installed. The power is owned by the Sheboygan Knitting Company and is leased to the Wisconsin Hosiery Mill. The dam is in good condition.

Upper Dam.—Only 1,000 feet above the middle dam is located the upper dam at Grafton, a crib dam 160 feet long. This dam supplies power for a grist mill located near the west end of the dam and also the Badger Woolen Mills located a little further down stream on the same race. The grist mill is owned by L. K. Ruck. The power is furnished by a 48 inch turbine under a 14 foot head. The owners of the flour mill report that they are entitled to three-quarters of the

water. The Badger Woolen Mill is run by an old style 48 inch turbine under a head of 15 feet. The dam and mills are in good condition. The banks are high enough to allow of several feet being added to the dam without overflow.

Saukville Dam.—In the 5 miles between Saukville and Grafton the river fall is only 15 feet. The river has low banks for this entire distance. Formerly a timber dam 200 feet long with a head of 6 feet was maintained at Saukville but the freshet of April, 1905, washed out the dam. The mill has not been operated for many years previous to 1905 and at the present time its roof has fallen in.

Fredonia Dam.—Between Saukville and Fredonia there are several good unimproved dam sites all located in the upper four miles. A dam with a 7 foot head was once located in Section 3, Township North, Range 21 East, but the mill burned down. At the south line of Section 9, Township North, Range 21 East, a dam 200 feet wide with a levee of same length would develop a head nearly 15 feet.

From the foot of the Fredonia dam to the bridge at Saukville, a distance of 185 miles the river falls 31 feet. At Fredonia a dam, 225 feet long with one 44 and one 48 inch turbine under a head of 5 feet, furnishes the power for a flour and feed mill. The owner, J. P. Pallanch has a charter for a 7.5 foot dam. Two-thirds of this dam is built of timber and stone and one-third of stone and concrete, all in the first class condition.

Newburg.—Two miles above Fredonia the North Branch of the Milwaukee River joins the main stream adding about 180 square miles of drainage area. In the eight miles between the foot of Newburg and the crest of the Fredonia dams the river falls a total of 54 feet the greater part of which is concentrated in the upper half of this distance. At the present time none of this fall is developed,[1] but the larger part of this fall could be developed by the following three dams.

(a) A dam about a half mile below the mouth of the North Branch about 250 feet long with a short levee would develop from 10 to 15 feet, but would flood considerable meadow land.

(b) A still shorter dam above the highway bridge near the south line of Section 31, Township 12 North, Range 21 East would develop 15 feet without any considerable flooding.

[1] Authority for this statement is the United States Geological Survey topographic map.

(c) A short dam in the southeast quarter of Section 6, Township 11 North, Range 21 East would develop about 12 feet without serious flooding.

Just above the bridge at Newburg is a timber dam 135 feet long and 8 feet high owned by Schumer and Stahl. This dam was first built in 1850 and partly rebuilt 12 years ago. The dam was repaired in the summer of 1905 and is now in good condition. The power is used to run a feed mill and saw mill both on the same race. At the feed mill two 42 inch and one 26 inch turbines are installed while at the saw mill the power is generated by two 42 inch and one 20 inch turbines all under a head of 12 feet. It seems likely that nearly two feet could be added to the height of the dam but considerable land would be thereby flooded.

In the ten miles above the foot of Newburg dam the river has a grade of 4 feet to the mile. For the entire distance the river has a sinuous course between comparatively low banks with little opportunity for a dam site.

WEST BEND POWERS.

In the next stretch of three or four miles the river changes from a southern to a nearly eastern course and in doing so breaks through a glacial moraine. This resulted in a fall of about 10 feet to the mile for this distance and originally included several rapids, now improved by three dams, located at Barton, West Bend, and one mile east of West Bend. The last will now be described.

This is a timber dam about 260 feet long including wings and in December, 1905, had a head of 7.3 feet. The banks are high and at least 3 feet could be added to the present head without flooding or interfering with the West Bend dam. The power was formerly used to run a flour and feed mill but at the present time is not running.

One and a half miles above this mill is located the West Bend dam and mill owned by Adam Kuchlthau. This is a timber dam 180 feet long and 8 feet high and is in good condition. The water is delivered to the mill by a long race which increases the head to 11 feet. This head could not be raised, as at present it backs the water nearly to the dam above at Barton.

One 90 inch and one 50 inch turbine furnish the power for both the flour mill and the city electric light plant, the latter supplemented by steam when needed. This dam has the largest pondage of any dam on the river.

Barton Dam.—This dam is located only a little over a mile above West Bend, and like the latter dam is only a few rods from the Chicago and Northwestern Railroad. The stone and timber dam is 170 feet long and is now in good condition. With one foot of flash boards it develops a head of about 12 feet. The turbine installation consists in three Laffel wheels 48, 42, and 30 inches in diameter. The power is used to run a flour and feed mill owned by William F. Gadow. As the banks are high the dam could be raised two feet without flooding. This would back the water to the site of the next dam above. The drainage area at this point is 160 square miles.

Young America.—Only a mile above Barton was formerly located, the Young America dam. This mill had a head of about 8 feet, but the dam is now out and both mill and town deserted.

Kewaskum Dam.—From the crest of the Kewaskum dam 7 miles above Barton to the crest of the Barton dam the river falls a total of 37 feet. Only 7 feet of this is at present developed and even that is not used. The river flows between low banks with few dam sites. The best dam site in this distance is that at Young America described above. A fairly good dam site is located just above the highway bridge two miles south of Kewaskum. A short dam would here develop a head of about 10 feet.

At Kewaskum an earth and timber dam 130 feet long in fair condition develops a head of 8.5 feet. A 54 inch turbine was here installed 30 years ago and used to run a grist mill. The mill property belongs to Backus and Stark, but at present no use is made of it. The drainage area above Kewaskum is 100 square miles.

Tributaries.—The principal tributaries of the Milwaukee river are Cedar Creek, East Branch, and Menominee rivers. In general, it may be said that the gradient of the tributaries is greater than that of the main river.

Tributaries of Milwaukee River.

CEDAR CREEK.

Cedar Creek has a drainage area of 100 square miles. Its source is in Cedar and Little Cedar Lakes at an elevation of about 1,030 feet and after an easterly course of thirty miles joins the Milwaukee river near Cedarsburg at an elevation of about 685 feet. Of the total fall of 350 feet about 250 are concentrated in two short stretches, about 140 feet being located in the 2.5 miles from Cedar Creek east-

ward and 108 feet in the 4.7 miles about the mouth. The lower concentration occurs in the Niagara limestone, but the upper consists in boulder rapids where the river breaks through the terminal moraine.

The following table gives a profile of the entire river.

Profile of Cedar Creek.

No.	Description of station.	Distance from mouth.	Distance between stations.	Elevation above sea level.	Descent between points.	
					Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river, Cedarburg	0.0	.....	685.‡	.....	.....
2	Sec. 35, T. 10 N., R. 21 E. foot dam	1.0	1.0	687.	2.0	2.0
3	Sec. 35, T. 10 N., R. 21 crest, dam	1.0	0.0	699.5	12.5	.....
4	Backwater of, above dam	1.5	0.5	699.5	0.0	0.0
5	E. ¼ post sec. 26, T. 10 N., R. 21. E.	2.8	1.3	720.0	20.5	16.0
6	Dam 2, nail factory, below	3.0	0.2	729.7	9.7	48.5
7	Dam 2, nail factory, crest	3.0	0.0	753.3	23.6	.....
8	Dam, 3, Columbian, below	3.3	0.3	754.0	0.7	2.3
9	Dam 3, Columbian, crest	3.3	0.0	765.0	11.0	.....
10	Backwarer, dam No. 3	4.0	0.7	765.0	0.0	0.0
11	Dam No. 4, Flouring, below	4.5	0.5	767.3	2.3	4.6
12	Dam No. 4 Flouring, crest	4.5	0.0	781.4	4.1	.....
13	Dam No. 5 Woolen, below ,.....	4.7	0.2	781.4	0.0	0.0
14	Dam No. 5 Woolen, crest	4.7	0.0	793.4	12.0	0.0
15	N. E. cor. sec. 9, T. 10 N. R. 21 E.	9.9	5.2	820.0	26.6	5.0
16	Center S. 5, T. 10 N. R. 20 E.....	20.4	10.5	840.0	20.0	1.9
17	C. & N. Ry. crossing, s. of Jackson	21.2	0.8	847.0	7.0	9.0
18	E. & W. ¼ line Sec. 6, T. 10 N., R. 20 E.....	22.7	1.5	860.0	13.0	9.0
19	Dam No. 6, Mayville	23.2	0.5	880.0	20.0	40.0
20	E. line Sec. 14, T. 10 N., R. 20 E.	24.2	1.0	900.0	20.0	20.0
21	.....	24.7	0.5	940.0	40.0	80.0
22	.....	25.2	0.5	980.0	40.0	80.0
23	Cedar Creek, dam	25.3	0.1	1,000.0	20.0	200.0
24	Little Cedar Lake, outlet	27.7	2.4	.....	.....	.....
25	Little Cedar Lake, outlet	29.2	1.5	.....	.....	.....
26	Big Cedar Lake, outlet	30.7	1.5	1,030.0	.....	.....

Author ty: No. 1 and 15, 16, 18, 19. 20, 21, 22, U. S. Geol. Survey Top. Map. 2—14, levels run by L. S. Smith. 17, C. & N. W. Ry.

That part included in the lower 5 miles was surveyed, the remainder is based upon the United States Geological Survey topographic map and railroad levels.

CEDARBURG POWERS.

(1) The first dam, located about one mile above the mouth of Cedar Creek is about 100 feet long and 7 feet high. The water is conducted through a long race and delivered to a flour mill owned by Kroehnke Brothers. One 48-inch turbine works under a head of 13 feet.

(2) One quarter mile above the Chicago, Milwaukee and St. Paul Railroad bridge over Cedar Creek in a very narrow limestone gorge is located a dam with a head of 245 feet used to run a nail mill. An additional 10 feet could be developed by moving this dam down stream about 1,000 feet.

(3) Only a few rods above this mill is a short stone and timber dam producing a head of 11 feet used to run the Columbia flour mill. Three turbines of about 60 horse-power are here installed.

(4) The Cedarburg Flour Mills is located about 80 rods above the Columbia Mill. A dam 10.5 feet high develops a head of 13 feet. One 40 inch turbine is installed. The power is owned by Ruck Brothers.

(5) About a half mile above the last named dam is located the Cedarburg Woolen Mills. A 40-inch turbine under a 12 foot head furnishes part of the power for this mill. The company also use two steam engines, one 35 and one 65 horse-power.

This is the last dam in this river in use to-day. The above 5 dams are seen to develop a total of 72.5 feet of an actual fall of 108 feet in 4.7 miles of river.

Above the Woolen Mills, the river continues to fall fast, so that one additional dam of 12 or 15 foot head could probably be put in above the back water of the woolen mill dam.

Four miles above Cedarburg the river valley widens out while the river gradient is also greatly reduced. The total fall between the Railroad bridge south of Jackson and the Cedarburg Woolen Mill, a distance of 16 miles, is only 53 feet and nearly all of this in the lower half of this distance.

In the four miles above the Jackson railroad bridge the river descends over 150 feet furnishing many good dam sites. Formerly there were six dams with heads of 15 to 22 feet but at present several of the mills have burned down and none of the dams are utilized for power.

These dams are not subject to the high floods of neighboring streams because of the controlling effect of the lakes above. By connecting these powers by electricity a valuable power could be produced. Mr. Dow Maxon of West Bend is largely interested in this property.

MENOMINEE RIVER.

This river has a length of about 30 miles and a drainage area of 130 square miles. The following profile shows the fall in detail. The average fall is 10 feet to the mile with two concentrations located at Wauwatosa and at Menominee Falls of about 60 and 24 feet respectively. The low water flow is very small.

Menominee Falls.—At one time there were three or more dams at Menominee Falls located only 20 or 30 rods apart but at present only one dam is utilized. This dam is used to run the Menominee Falls Roller Mills, owned by W. F. Lepper and Company. The lower dams were used to run a saw mill and sash factory.

Wauwatosa Dam.—This water power, known as the Wauwatosa Milling and Lumber Company, is owned by Velgesen and Hardey. One 20-inch turbine is used under a 17 foot head for grinding feed and sawing cord wood. The banks are high enough to allow for a large increase in the head on this dam.

Profile of Menominee River (Branch of Milwaukee).

No.	Description of Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet	Feet.	Feet.
1	Mouth of river, Milwaukee	0.0	0.0	581.3	.....	.....
2	St. P. Ry. bridge, N. E. ¼ S. 26, T. 7 N., R. 21 E.....	4.0	4.0	605	13.7	3.4
3	St. P. bridge, below dam, Wauwatosa	6.5	2.5	639	34	13.7
4	N. W. ¼ S. W. ¼, S. 21, T. 7 N., R. 21 E.....	7.0	0.5	663	24	48.0
5	S. W. ¼ N. E. ¼, S. 17, T. N., R. 21 E.....	10.7	3.7	680	17	4.7
6	S. line S. 6, T. 7 N., R. 21 E.....	12.2	1.5	700	20	13.3
7	N. line S. 36, T. 8 N., R. 20 E....	15.0	2.8	720	20	7.1
8	E. & W. ¼ line S. 19, T. 8 N, R. 21 E.	16.5	1.5	740	20	13.3
9	C., M. & St. P. bridge, Menomonie Falls	21.5	5.0	836	96	19.2
10	C. & N. W. Ry. bridge near Germantown	27.0	5.5	854	18	3.3

Authority: 1. U. S. Lake Survey; 2, 3, 9, C. M. & St. P. Ry.; 4-8, U. S. G. S. Topog. Map; 10 C. & N. W. Ry.

Northeast branch of Milwaukee Rivers—The following water powers are reported on this tributary.

Locality.	Owner's Name.	Turbines.		Business.
		Head.	H. P.	
Cascade	A. J. Lammers.	13	20	Feed mill.
Cascade	Wm. Timm	16	20	Feed mill.
Dundee	Leo Arimond	15	78	Electric light.
Section 20, T. Lyndon		10		Undeveloped.
Sec. 17, T. 13, N., R. 21 E	Mrs. B. Young	8	20	Feed mill.
Sec. 8, T. 13 N., R, 21 E	Aug. Capell	4	15	Saw mill (not running.)
N. E. Sec. 26, T. 13 N.. R. 18[E]				Saw mill.
Ashford				Grist mil.
New Castle				Flour mill.
Jersey				do
Eblesville				Saw mill.
Sec. 26, T. 14, R. 15 E.				
Random Lake				Flour mill.

Railroad Facilities.

The Milwaukee river has exceptionally good railroad facilities. The lower half of the river is paralleled by both the Chicago, Milwaukee and St. Paul and the Chicago and Northwestern railroad, the former on the right and the latter on the left side of the river. Between Kewaskum and West Bend the Chicago and Northwestern railroad follows the river very closely leaving only that part of river lying between West Bend and Fredonia unserved by railroad.

SHEBOYGAN RIVER.

Geology and Drainage.

Sheboygan and Manitowoc Rivers rise within two or three miles of the east shore of Lake Winnebago at an elevation of about 400 feet above Lake Michigan. The western slope of this divide is very precipitous due to the erosion of the shales exposing ledges of limestone. Almost the entire area is underlayed by the Niagara limestone which, however, is deeply covered by the glacial drift.

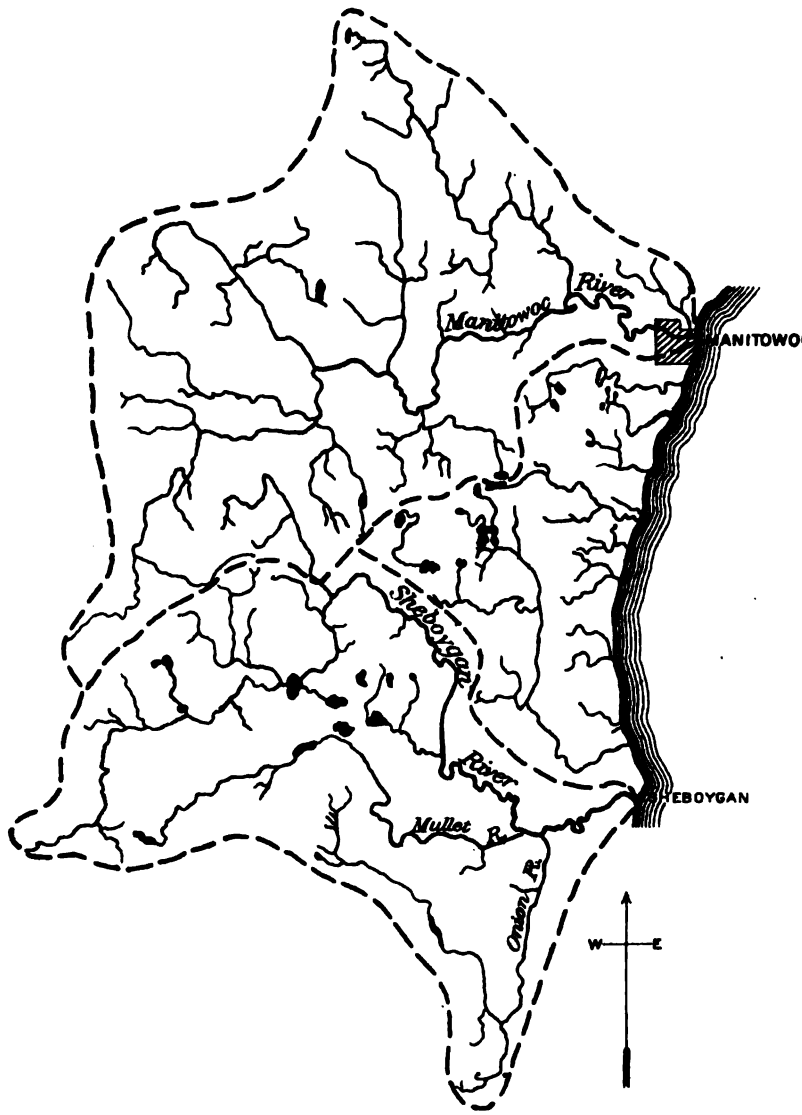
The Kettle range crosses the drainage in about the middle of the river's course and in a direction parallel to Lake Michigan. In crossing this range of hills, the Sheboygan River is compelled to take a very circuitous course to the northward, thence east across the range and southward again before starting on its final course eastward to Lake Michigan.

The total drainage area of the river is 380 square miles, but Onion River does not join the main river until within five miles of Lake Michigan, while Mullet River, a still larger tributary, joins the Sheboygan less than two miles above the mouth of the Onion. These two facts lessen the importance of the Sheboygan as a power producer.

FALL OF THE RIVER.

In the 40 miles between Kiel and the mouth of the river, the total fall is 306 feet, or an average of 7.6 feet per mile. The largest and most important concentration of fall is located between the mouths of Mullet and Onion Rivers. This fall at present amounts to 42 feet. Its occurrence there, has no doubt determined the location of the city of Sheboygan Falls. A survey of the river from this point to the mouth was made in November, 1906.

The following profile gives with considerable detail the gradient of



MAP
OF
DRAINAGE AREA
OF
MANITOWOC AND SHEBOYGAN
RIVERS

SCALE 1" = 10 MILES

0 5 10 15 20 25 MILES

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the main river. There is reason for the belief that the fall in the two tributaries, Mullet and Onion River, is quite as great as in the parent river.

Profile of Sheboygan River.

No.	Station.	Distances. From mouth.	Distances. Between points.	Elevation above sea level.	Descent between points. Total.	Descent between points. Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	0.0	.....	581.2	.....	.....
2	R.R. bridge, W. Lina Sec. 2, T. 15 N., R. 23, E	3.0	3.0	581.28	.08	0.03
3	Highway bridge, center of Section 28	3.5	0.5	584.28	3.0	6.0
4	N.E.¼, S.W. ¼, Sec. 29, T. 15 N., R. 23, E	5.7	2.2	589.28	5.0	2.3
5	S. E. ¼, S.E. ¼, Sec. 30, T. 15 N ,R. 23, E	10.3	4 6	608.	18.7	4.1
6	S. E. ¼, N. W. ¼, Sec. 31, T. 15, N., R. 23, E	12.0	1.7	611.60	3.6	2.1
7	150 feet below Onion R	13.3	1.3	617.44	5.84	4.5
8	Lower Dam Sheboygan Falls, foot.	13.5	0.2	634.57	17.13	85.6
9	.....do.... crest	.....	....	651.18	16.61	....
10	Upper Dam, Sheboygan Falls, foot	13.7	0.2	651.38	0.2	1.0
11	.....do.... .....crest.	.....	....	659.68	8.3	.....
12	Kiel, below dam	40.0	26.4	877.	117.3	4.4
13	Kiel, above dam	40.0	....	887.	10.	.....
14	Sec. 6, T. 16 N., R. 21 E	43.0	3.0	.....	.....	. .....
15	Sec. 18, T. 16 N., R. 21 E	45.0	2.0	.....	.....	.....
16	East of St. Cloud	54.0	9.0	.....	.....	.. ....

Authority: Points 1—11, levels by J. Donohue under the direction of L. S. Smith. 12—15, Chicago, Milwaukee and St. Paul Railway. 16, Chicago and North Western Railway.

Water Powers.

No other river in the state of equal size, thus far investigated, has so many developed water powers as has Sheboygan River. While no one single power has any great importance, the general distribution of over 30 water powers in the county is a matter of considerable importance. The number of powers which have been allowed to go back to a state of nature is remarkably small, considering the high value of farm land in this locality.

Many of the existing powers could easily and cheaply increase their developed head as well as profit by the installation of improved modern turbines.

The following tabulation gives the most important facts regarding these powers which is available.

Water powers on the Sheboygan River and tributaries.

River.	Location.	Turbines.		Owner.	Used for.
		Head	H. P.		
Onion	S. W. S. W., S. 1, T. 12, R. 22 E.	12	.....	Harvard Giddings	Not used now.
.. do	S. W. N. W., S. 12, T. 12, R. 22 E.	11	.....	Mr. Drussel	do do
.. do	Hingham	12	65	J. W. Hyck & Son	Flour and feed.
.. do	Waldo	10½	70	S. E. Wierman	do do
.. do	Winooski	.....	.....	.....	
.. do	¾ mi. E. of Hingham	7	35	Mrs. Henry Hobart	Saw mill.
.. do	S. E. of N. E., S. 32, T. 12, R. 22 E	8	.....	Christ Flaig	Dam gone.
.. do	S. E. S. E., S. 26, T. 12, R. 22 E.	..	33	James Lammers.	Feed mill.
.. do	Sec. 1, T. 14 N., R. 22, E.	15	.....	.....	Undeveloped.
.. do	Sec. 12, T. 14 N., R. 22 E.	10	.....	.....	do
Mullet	Sec 27, T. 15 N., R 21 E	.....	.....	.....	
.. do	Three miles above Plymouth	14	.....	G. Pfuffer	do
.. do	Plymouth	16	40±	P. Brickhauer	
.. do	do	12	75	G. Pfuffer	Flour mill.
. do	Glenbeulah	8	70	B F. Avery	Abandoned at present.
do	Greenbush	9	18	Frank Avery	Flour and feed.
.. do	do	9	40	R. Herrling	Saw mill.
.. do	Sec. 35, T. 15 N., R. 22 E.	16	.....	.....	.....
Sheboygan.	Sheboygan Falls	16	680	Brickner Woolen Mills	Manuf. woolens.
.... do	do do	9	110	R. H. Thomas & Sons	Roller mills.
.... do	Sec. 26, T. 15 N., R 22 E.	8	49	Chas. Kroeger	Saw mill.
.... do	Sec. 6, T. 15 N. R. 22 E.	8	50±	C. H. Schultz	Flour and feed.
.... do	Sec. 19, T. 16 N., R. 22 E	14	50±	Arpke Bros	Flour and saw mill.
.... do	Millhome	7	44	W. Eikhoff	Flour and feed.
.... do	Rockville	10	50	.....	Flour and saw mill.
.... do	Kiel	11	50	Kiel Flour Co	Flour mill.
.... do	Mt. Calvary	14	40	Frank Bean	do
.... do	Sec. 21, T. 15 N., R. 22 E	9	65	Wm. Dassow.	Flour and feed.
.... do	Sec. 22, T. 15 N., R 22 E.	10	54	H. S. Goodwin	Not used.
.... do	Sec 27, T. 15 N., R. 22 E.	5	35	Chas. Kroeger	do

MANITOWOC RIVER.

Geology and Drainage.

The geology of the Manitowoc River valley is simliar to that of the Sheboygan. Like Sheboygan River, it rises within three miles of the eastern shore of Lake Winnebago and joins Lake Michigan only after a very circuitous course due largely to the difficulty of penetrating the glacial moraine in this locality.

This river has a total drainage area of about 505 square miles, which is 125 square miles more than that of Sheboygan River.

Fall in the River.—As the river is crossed by railroads but a few times, detail knowledge concerning its fall is lacking. From the following data, it is seen that, in the upper half of its length, the river has a comparativly flat gradient, viz.: 2.7 feet per mile. In the last 26 miles of its course, however, its fall is 8.3 feet per mile, which should insure many chances for the development of power.

Profile of Manitowoc River.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of River	0.0	.....	581.20	.....	.....
2	S. W. ¼. S. W. ¼ Sec. 31, T. 19 N, R. 22 E. (West of Valders)	26	26	797·00	215.8	8.3
3	Chilton, C., M. & St. P. Railway Bridge	44	18	847.00	50.0	2.7

Developed water power on Manitowoc River.

River.	Location.	Turbine.		Owner.	Used for.
		Head	H. P.		
Manitowoc	Manitowoc Rapids	7	100	Ourada Brothers.	Grist Mill.
"	Oslo	12	100	Stephenson Bros.	Flour and Woolen.
"	Clark Mills	.....	50	Wm. Weinke	Flour Mill.
"	Cato Falls	.....	.....	.....	Abandoned.
South Branch, Manitowoc	Gravesville	.....	.....	.....	Sawmill.
South Branch, Manitowoc	Hayton	.....	.....	.....	Flour.
South Branch, Manitowoc	Chilton	25	42	Dumke & Rasch.	Flour, Feed.
Branch River	Lenaville	.....	.....	.....	Flour.

ROCK RIVER.

Topography and Drainage.

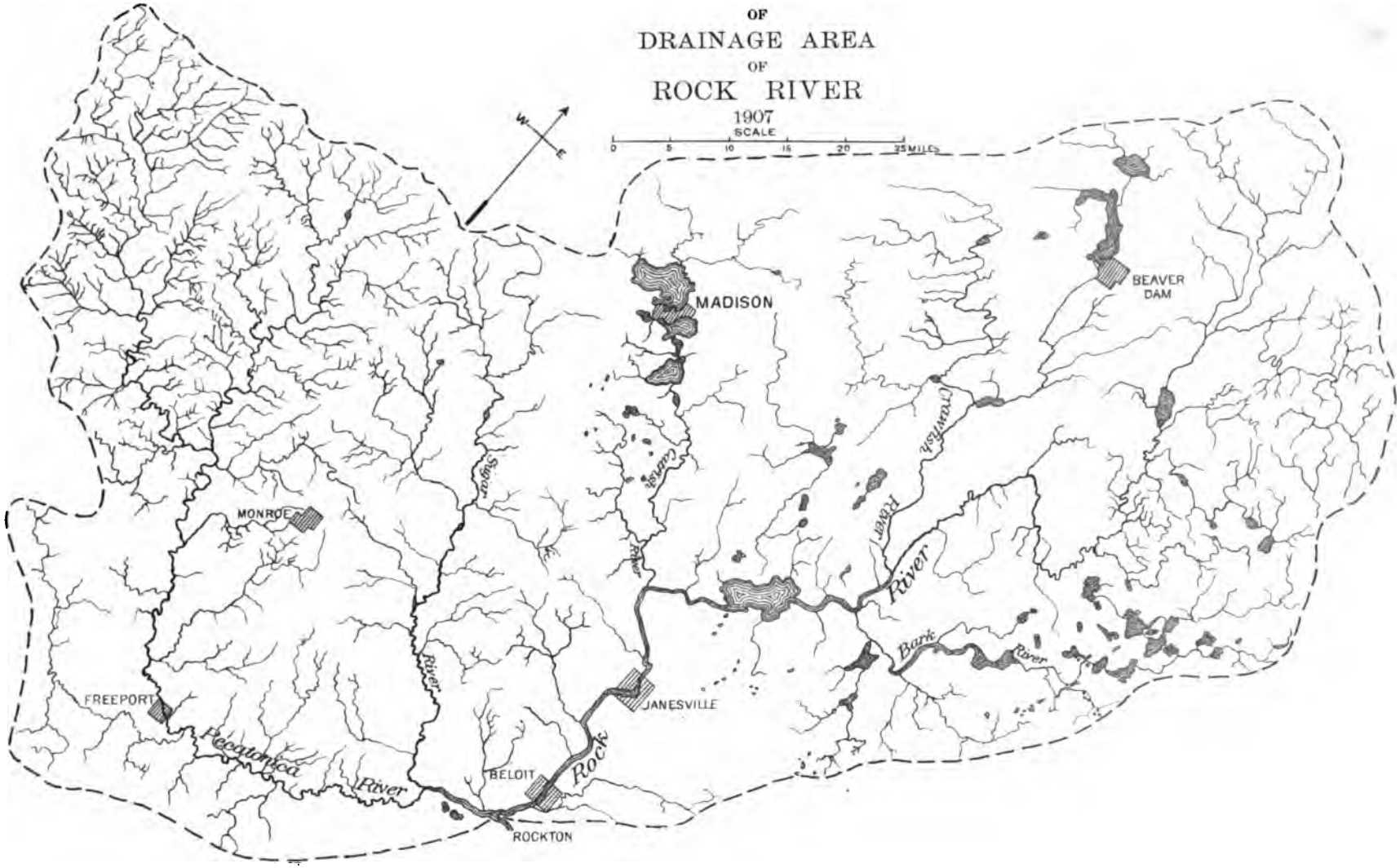
The Rock River occupies the southern half of a depression that extends from Green Bay and Lake Winnebago southwestward to the southern limit of the state. About twenty miles north of the state line this valley is interrupted by the glacial drift of a moraine known as the "Kettle Range," a moraine which also forms over half of the eastern boundary of the valley. A series of ledges and cliffs extend along the western side of the Kettle Range and overlook the extreme northern sources of the river.

The drainage immediately north of the Rock Valley is into Lake Michigan. The total drainage area of the river above the state line is approximately 3,500 square miles. This does not include the valley of the Sugar and Pecatonica rivers which join the main river a few miles below Beloit. The Rock Valley has an extreme length and width of 85 and 65 miles, respectively. "The surface is moderately hilly varying from 750 feet where the river enters the state of Illinois to 1,100 feet above the sea on the crests of the Kettle Range. The rise from the interior of the valley is gradual, and usually the hilltops are not more than 100 feet above the intervening valleys. This low uneven topography has led to the formation of an intricate tributary system with numerous spring fed lakes."[1] These lakes occur chiefly in an eastern and western group, the former comprising about 20 lakes with an aggregate area of 11 square miles and the latter group including 5 lakes with a total area of 13 square miles. Lake Koshkonong, an expansion of Rock River, is the only body now controlled in the interests of manufacturing. Its area is 23 square miles. The controlling dam is 4 miles below the real foot of the lake. The total cost of this dam, land damages, etc., was $30,000,

[1] Bulletin in 44 United States Bureau of Forestry.

MAP OF DRAINAGE AREA OF ROCK RIVER

1907



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and was borne by the following water powers in the proportions stated; Janesville 29.5 per cent, Beloit 29.5 per cent, Rockford 25 per cent, Rockton 16 per cent. The lake can be drawn down 5 feet through a 40 foot gate opening. In time of low water the lake is drawn upon to the extent of 15 per cent of the corresponding river below. The capacity of the lake could be very greatly increased. Mr. Frizell states that there is no physical obstacle to the erection of a dam 20 feet high, but it would involve very heavy damages by greatly extending the lake area and flowing out mill privileges above. While such an improvement would greatly enhance the value of all powers below, it now seems doubtful whether the cost of this project would be justified by the benefits conferred.

The restoration of Lake Horicon to its condition prior to 1868 would have an even greater effect in regulating the flow of the river. At that time Lake Horicon had an area of about 50 square miles imponded partly by a short dam built as early as 1842, and partly by a natural dam, caused by glacial drift. The water power report of the tenth census states that the dam had a head of 9.5 feet creating a power of about 500 horse-power. This dam was removed as the result of a court decision against the owners because of damage to land-owners, but while it existed it exerted an important influence. Doubtless, it was the hope of many that the removal of the dam would sufficiently drain the marsh above to make the lands suitable for agriculture. This has not proved to be the fact because of the natural dam in Horicon and probably the back-water of the next dam below at Hustisford. At the present time there is a petition before the circuit court for the organization of a drainage district for the better drainage of the Horicon marsh. This plan includes the removal of the present dam at Hustisford. If this improvement is made, its effects upon the water powers of the Rock River will be to still further reduce the low water flow and add to the flood flow, because even at present the Horicon Marsh stores up a large amount of water and by its low gradient and tortuous course largely delays the passage of the waters through it.

Other lakes worthy of mention are Beaver Dam and Fox Lake, the former being 7 miles long and three-quarters of a mile wide at the head-waters of Beaver Dam River.

The following table gives the drainage areas of the river:

Distances and drainage areas of Rock River in Wisconsin above Beloit.

River.	Distance.		Drainage area above station.
	From source.	Between station.	
	Miles.	Miles.	Square miles.
Above Horicon	25	25	500
Above Watertown	82.5	57.5	1,030
Crawfish, above mouth, Jefferson	97.5	15	1,100
Crawfish, below mouth, Jefferson	97.5	0	1,820
Bark, above mouth, Fort Atkinson	105.5	8	1,920
Bark, below mouth, Fort Atkinson	105.5	0	2,250
Catfish, above mouth	125.8	20.3	2,620
Catfish, at mouth	125.8	0	3,200
Beloit, state line	154.1	28.3	3,500

GEOLOGY.[1]

The Pre-Cambrian rocks are everywhere deeply covered by the Paleozoic rocks. The southern slope of this rock is favorable for conveying some of the percolating waters from the north down to the southeastern part of the state where they reappear as springs.

The principal source of the water supply within this drainage basin is of course the precipitation, and the economy of its distribution depends largely upon the character of the surface upon which it falls. The pot hole topography, for example, is not favorable to producing a large run-off.

The soil conditions vary on different parts of the water shed according to the exposure of the different layers of rock. In the west and northwest, the headwaters of the river, are the Potsdam sandstone, the lower magnesian St. Peter sandstone, and Trenton limestone, and over, the glacial drift that has covered these deposits. The main part of the drainage, however, lies over the area of the Galena and Niagara limestone and the Cincinnati shales.

These formations all allow more or less free percolation of water, hence the geologic conditions favorable to a sustained and ample flow of the river.

A few miles above Fort Atkinson the river leaves the Trenton limestone, and runs in the St. Peter sandstone the entire distance to the southern boundary of the state. The result is, that while the

[1] Condensed from Bulletin 44, United State Bureau of Forestry, by G. E. Schartz.

water powers at Hustisford and Watertown have hard limestone beds and banks, the power below in the sandstone section have gravel as a foundation for the dams. Considerable trouble has been experienced both from their instability and the permeability of the foundations.

The western extension of the Rock River in Wisconsin drained by the upper waters of the Pecatonica, lies in the driftless area so that rock bottoms are the rule in this region.

FOREST AND RAINFALL.

This region at the time of its settlement some 60 years ago was extensively covered by forests of hardwood on the uplands and tamarack, cedar, spruce, and willow in the swamps. The total area at that time may be conservatively estimated at 75 per cent allowing 5 per cent for water surfaces, this would leave 20 per cent to be divided equally between prairie and marsh land.[1]

Since the settlement of the region a large part of the forests have been removed and the land brought under cultivation. Most of the prairies are now cultivated and many swamps drained. The division of the surface may be now estimated as follows:

Forest	30 per cent
Cultivated land	57 per cent
Swamps and uncultivated meadows	8 per cent
Water surface	5 per cent

Not only have the wooded areas diminished but even in the persisting forests the natural undergrowth of moss, seedlings, and shrubs, with the accompanying rich receptive mold, have to a great extent been lost as a result of pasturage. The effect of these changes has been for the rainfall to get to the rivers in a much shorter time than formerly thereby decreasing the low water flow.

The following diagram shows clearly the rainfall in the valley of the Rock river since the year of 1893. The diagram also shows the distribution of the rainfall between the storage, growing and replenishing periods. The rainfall year here begins with December.

[1] These estimates are from Bulletin 44, ante.

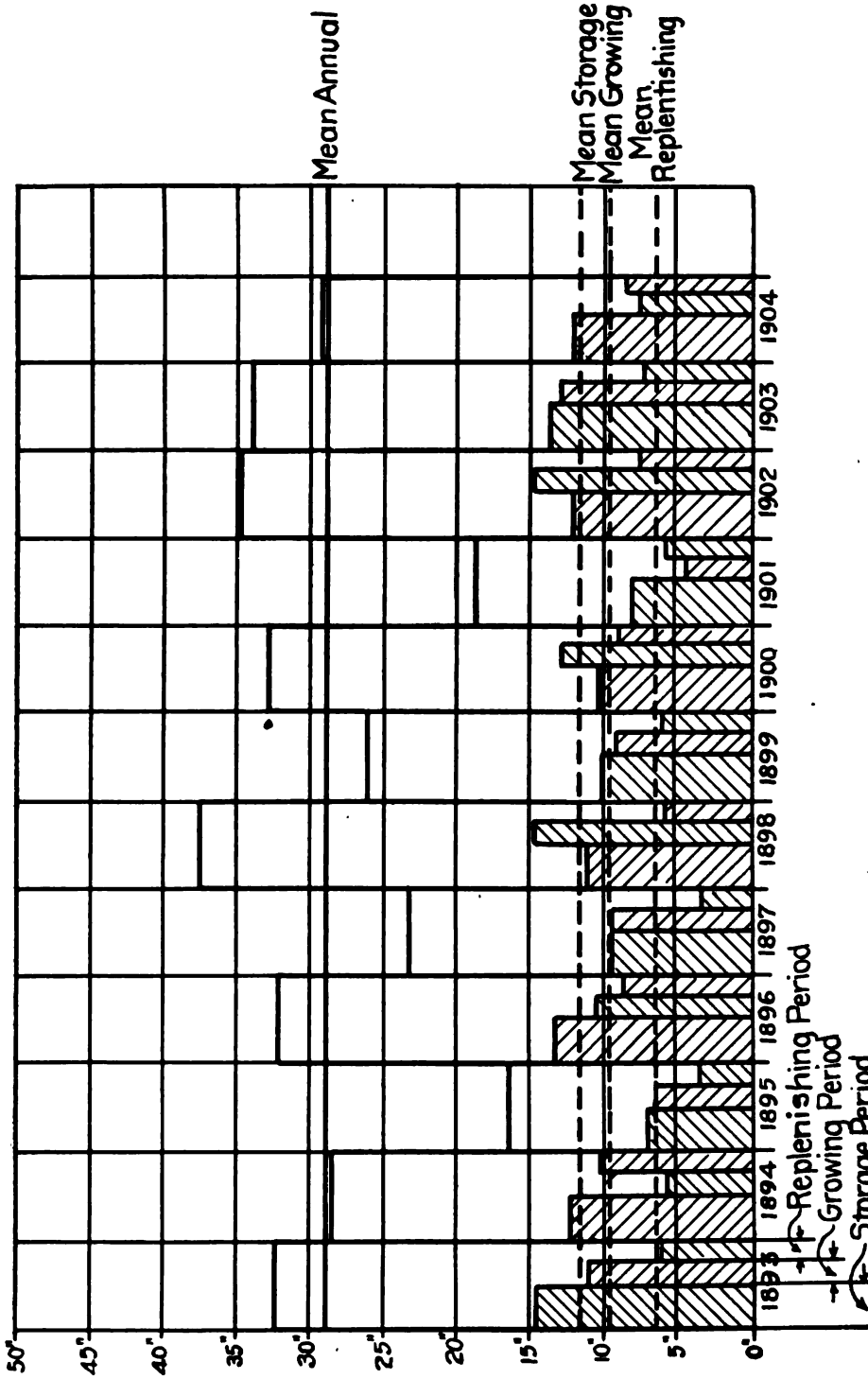

Fig. 15.—Rainfall on the watershed of Rock River above Rockton, Illinois.

Rainfall in the Rock River Valley, 1885–1907.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1885	1.8	0.8	0.4	3.2	1.2	5.9	4.8	7.7	4.0	2.7	1.0	2.9	36.4
1886	4.1	1.6	4.2	2.9	2.4	2.2	1.0	4.5	2.2	2.4	1.3	1.5	30.3
1887	2.8	4.2	1.6	1.0	1.6	.9	4.1	5.0	5.0	2.7	1.2	4.1	34.2
1888	1.4	1.1	2.1	2.3	3.9	3.4	4.0	2.5	1.5	1.9	1.8	2.5	28.4
1889	1.9	2.5	1.3	2.2	4.3	4.7	2.0	1.0	2.2	.3	2.0	2.5	27.8
1890	2.4	1.9	2.1	3.1	4.1	7.1	1.2	3.1	1.4	4.4	2.1	1.0	33.9
1891	1.6	1.3	2.5	3.2	1.5	4.1	2.9	1.7	.3	1.8	3.1	2.2	25.2
1892	2.4	1.7	1.6	3.2	7.5	7.9	2.4	3.1	2.5	1.5	1.5	1.8	37.1
1893	1.5	1.4	2.6	5.1	2.0	3.9	3.2	1.5	2.7	2.4	1.3	2.3	29.9
1894	1.6	.8	2.4	3.4	4.0	3.6	1.2	.9	5.8	2.2	2.4	3.5	29.1
1895	1.6	.6	.8	1.2	4.0	2.0	2.4	3.2	1.8	.5	2.3	2.0	22.4
1896	.9	.8	1.6	4.2	4.9	2.6	4.3	2.2	6.4	1.1	3.0	7.0	31.7
1897	2.9	1.3	3.2	4.0	1.0	4.7	2.8	2.8	1.5	1.1	1.5	1.7	28.5
1898	2.3	2.0	3.2	2.1	3.0	4.8	3.1	3.8	2.3	3.9	1.2	.5	32.2
1899	.6	.7	1.5	1.9	5.1	3.4	3.1	2.8	3.0	1.7	1.7	1.7	27.2
1900	1.5	2.3	1.6	2.5	1.9	1.9	6.7	4.0	2.7	3.6	2.3	.6	31.6
1901	1.1	1.2	2.8	.5	2.4	1.8	2.7	1.0	3.2	1.8	.8	1.3	20.6
1902	.4	1.5	1.2	1.2	6.3	4.9	9.2	.8	4.2	1.4	2.3	2.1	35.5
1903	.5	1.4	3.0	3.1	4.0	1.6	5.8	6.8	4.5	2.4	1.6	1.2	35.9
1904	.6	1.5	2.3	1.8	4.4	1.9	3.5	3.2	5.4	2.4	0.2	2.6	29.8
1905	1.4	1.6	2.0	2.1	6.3	5.3	2.7	4.6	1.2	2.9	2.4	1.0	32.5
1906	2.8	1.4	2.1	1.4	3.8	4.2	2.1	5.8	2.5	2.6	2.8	1.5	33.0
1907	2.5	0.3	2.1	3.2	3.2	4.5	6.9	3.6	5.7	1.2	1.4	1.2	35.8

RUN-OFF DATA.

The United States Geological Survey has never established a gaging station on the Rock river in Wisconsin, but a station has been maintained a few miles south of the state line for three years at

Rock River Below Pecatonica Creek at Rockton, Illinois.

This station was established May 13, 1903, by E. Johnson, Jr., assisted by L. R. Stockman. It is located at the village highway bridge, one-half mile from the Chicago, Milwaukee and St. Paul Railroad station, one mile below the dam, and three-fourths of a mile below the junction of Pecatonica River with Rock River. There are small islands a short distance above and immediately below the station. The chain gage is located on the first span from the left end of the bridge, on the down stream side. The gage is read twice each day by O. T. Bartholomew. The length from end of weight to marker is 26.45 feet. Discharge measurements are made from the upstream side of the five-span highway bridge to which the gage is attached. The initial point for soundings is the face of the abutment on the left end of the bridge. The channel is straight for 2,000 feet above and 1,000 feet below the station. Both banks are

high and will not overflow. The channel is about 565 feet wide between bridge abutments and is broken by four piers. The bed of the stream is composed of small rocks and gravel.

Bench mark number one is a hammered cross on the top stone of the left abutment about one foot from the bridge shoe and one foot from the south edge. Its elevation above gage datum is 16.85 feet. Bench mark number two is the top of the west end of the south rail of the railroad track, 250 feet north of the north end of the bridge, at a point where the sidewalk on the west side of the street crosses the track. Its elevation above gage datum is 16.49 feet.

The following tables give the gage readings rating table and monthly discharges at Rockton for 1903, 1904, 1905, 1906 and 1907.

Mean daily gage height, in feet, of Rock River below Pecatonica Creek at Rockton, Ill., for 1903.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1903.							
1	.....	2.50	4.10	4.40	3.70	3.10	2.70
2	.....	2.60	.....	4.30	3.60	3.20	2.80
3	.....	2.90	.....	4.20	3.70	3.20	2.70
4	.....	3.70	.....	4.10	3.50	3.10	2.70
5	.....	3.50	.....	4.00	3.70	3.10	2.80
6	.....	3.40	.....	3.90	3.70	3.00	2.70
7	.....	3.40	.....	.....	4.00	2.90	2.60
8	.....	3.30	.....	3.60	6.00	2.60	2.60
9	.....	3.00	4.10	4.00	5.40	2.70	2.70
10	.....	3.30	4.00	4.10	5.10	2.60	2.60
11	.....	3.50	3.60	4.30	5.00	2.80	2.70
12	.....	3.90	3.20	4.50	4.70	2.90	2.60
13	.....	4.70	3.20	4.30	4.60	3.20	3.80
14	.....	4.60	3.10	5.00	4.40	3.40	3.30
15	.....	4.10	3.40	5.30	4.40	3.30	3.30
16	.....	3.90	3.70	5.70	4.40	3.30	3.40
17	.....	4.00	4.30	5.90	4.30	3.20	3.20
18	.....	3.80	4.20	6.00	4.30	2.70	3.00
	.....	5.20	3.80	5.70	4.00	3.00	3.30
20	.....	5.70	3.60	5.30	4.10	2.90	3.30
21	.....	6.20	3.50	5.00	4.00	3.00	3.20
22	.....	5.90	3.40	4.80	4.00	2.90	3.20
23	.....	7.20	3.40	4.60	3.80	2.90	3.20
24	.....	7.00	3.50	4.40	3.80	2.80	3.10
	.....	6.70	3.40	4.00	3.60	2.80	3.10
26	.....	5.80	3.30	3.90	3.60	2.50	3.20
27	.....	4.60	3.60	3.80	3.50	3.10	3.10
28	2.40	4.60	3.90	4.00	3.40	2.70	3.00
29	2.20	4.10	4.30	3.90	3.30	2.90	3.10
30	2.70	4.20	4.60	3.80	3.30	2.90	3.10
31	.....	4.20	4.40	.....	3.10	.....	3.00

Mean daily gage height, in feet, of Rock River at Rockton, Ill., for 1904.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1904.												
1	2.90	2.90	3.80	10.65	4.53	3.68	2.20	2.10	2.15	3.50	2.65	2.20
2	2.90	2.90	3.95	9.61	4.50	3.68	2.20	1.90	2.15	3.25	2.60	2.15
3	2.90	3.10	6.00	8.85	4.30	3.51	2.25	1.80	2.20	3.15	2.45	2.20
4	3.00	3.20	6.72	8.37	4.18	3.00	2.20	1.80	2.12	3.00	2.50	2.20
5	2.90	3.00	6.83	8.06	4.05	3.20	2.15	1.80	2.30	2.85	2.45	2.25
6	2.80	2.80	6.60	7.85	4.01	3.10	2.15	1.90	2.60	3.20	2.45	2.20
7	2.90	4.50	7.45	7.60	4.00	3.10	2.30	1.95	2.45	3.25	2.25	2.20
8	2.90	5.50	9.92	7.60	4.18	3.11	2.40	1.90	2.35	3.10	2.45	2.20
9	2.90	5.90	10.80	7.60	4.50	3.00	2.50	1.82	2.30	2.75	.....	2.20
10	3.00	6.10	11.12	7.60	4.85	2.95	2.46	1.90	2.31	3.00	2.45	2.20
11	2.60	6.00	11.10	7.61	4.79	2.95	2.35	1.85	2.30	3.40	2.45	2.20
12	2.90	5.80	10.90	7.41	4.76	2.85	2.35	1.75	2.20	3.81	2.50	2.20
13	2.90	5.50	10.30	7.10	4.81	2.80	2.40	1.80	2.20	4.25	2.40	2.40
14	3.00	4.70	9.33	6.83	4.81	2.75	2.25	1.70	2.26	4.25	2.20	2.45
15	2.80	4.10	8.85	6.50	4.91	2.70	2.20	1.85	2.20	4.50	2.30	2.70
16	2.90	3.90	8.00	6.40	4.95	2.60	2.13	1.55	2.15	3.80	2.45	2.85
17	3.00	3.80	6.34	6.20	4.99	2.62	2.00	1.75	2.10	3.30	2.45	2.70
18	2.70	3.80	5.50	5.91	4.81	2.55	2.10	1.90	2.20	3.15	2.35	3.00
19	3.00	3.60	4.90	5.79	4.80	2.65	2.10	1.75	2.90	3.50	2.45	2.65
20	3.00	3.60	8.35	5.60	4.68	2.50	2.10	1.90	4.00	2.90	2.40	2.90
21	3.10	3.70	8.35	5.48	4.60	2.50	2.00	1.95	3.80	2.75	2.20	2.80
22	3.10	3.60	12.75	5.35	4.48	2.50	2.00	2.50	3.25	2.70	2.30	2.70
23	3.20	3.50	13.23	5.16	4.32	2.50	2.00	2.80	2.80	2.70	2.30	2.45
24	3.30	3.30	12.05	5.18	4.28	2.45	2.00	3.00	2.55	2.75	2.20	2.50
25	3.20	3.50	12.25	5.53	4.31	2.40	1.75	3.10	2.35	2.70	2.30	2.50
26	3.30	3.50	12.55	5.55	4.18	2.35	2.10	2.70	2.65	2.65	2.40	2.50
27	3.30	3.60	12.40	5.31	4.10	2.15	2.60	2.30	3.35	2.65	2.20	3.00
28	3.10	3.60	12.30	5.04	3.90	2.20	2.10	2.40	4.20	2.70	2.20	4.20
29	3.00	3.80	11.85	4.80	3.85	2.20	2.00	2.10	4.12	2.60	2.20	5.10
30	2.90	.....	11.45	4.63	3.79	2.20	2.00	2.20	3.65	2.55	2.30	5.15
31	2.90	.....	11.16	.....	3.80	.....	2.00	2.30	.....	2.75	.....	4.60

[1] River partially frozen January 1 to March 27, and December 13 to 31.

Rating table for Rock River at Rockton, Ill., from January 1, 1904, to December 31, 1905.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.5	810	2.8	2,470	4.2	4,940	8.0	14,020
1.6	910	2.9	2,620	4.4	5,345	8.5	15,270
1.7	1,015	3.0	2,775	4.6	5,760	9.0	16,520
1.8	1,125	3.1	2,935	4.8	6,180	9.5	17,770
1.9	1,235	3.2	3,105	5.0	6,620	10.0	19,020
2.0	1,350	3.3	3,280	5.2	7,070	10.5	20,270
2.1	1,470	3.4	3,455	5.4	7,540	11.0	21,520
2.2	1,600	3.5	3,635	5.6	8,020	11.5	22,770
2.3	1,740	3.6	3,815	5.8	8,250	12.0	24,020
2.4	1,880	3.7	3,995	6.0	9,020	13.0	26,520
2.5	2,025	3.8	4,180	6.5	10,270		
2.6	2,170	3.9	4,365	7.0	11,520		
2.7	2,320	4.0	4,555	7.5	12,770		

This table is applicable only for open channel conditions and is based upon 17 discharge measurements. It is well defined between gage heights 2.4 and 6.0. One flood meaasurement at 12.32 fixes the upper part of the curve.

Daily gage height, in feet, of Rock River at Rockton, Ill., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.												
1	4.0	[1]3.1	4.0	10.1	4.2	4.3	4.3	2.8	2.8	2.3	2.6	3.5
2	3.8	3.2	5.0	9.4	4.1	4.25	4.3	2.75	2.95	2.05	2.6	3.5
3	4.55	[1]3.2	5.4	8.9	3.8	4.2	4.3	2.7	3.85	2.2	2.7	3.0
4	3.9	3.15	6.2	8.7	3.8	4.2	4.1	2.65	3.4	2.2	2.6	3.2
5	3.65	3.15	6.1	8.4	3.6	4.3	4.0	3.15	3.5	2.15	2.65	3.1
6	3.45	3.1	5.8	8.3	3.65	5.0	3.9	3.1	3.45	2.2	3.0	3.15
7	3.3	3.25	5.7	8.1	3.6	4.85	4.0	3.0	3.4	2.15	2.9	3.05
8	3.5	3.25	5.5	7.8	3.55	4.9	4.05	3.0	3.4	2.1	3.1	3.05
9	3.5	3.25	5.5	7.6	3.4	5.1	3.95	2.75	3.3	1.9	3.1	3.0
10	4.2	3.25	6.4	7.4	3.55	5.3	3.95	2.7	3.3	2.0	3.15	3.0
11	4.0	3.3	6.2	7.2	3.95	5.2	4.0	2.65	3.4	2.0	3.0	3.1
12	4.1	3.3	5.6	6.8	5.8	5.4	4.05	2.6	3.15	2.1	2.8	2.95
13	3.75	3.4	6.5	6.5	6.0	5.4	4.2	2.5	3.05	2.05	2.8	2.85
14	3.85	3.15	5.5	6.3	6.4	5.4	4.2	2.8	2.9	2.1	3.0	2.85
15	4.0	3.2	5.3	6.0	7.0	5.3	4.1	2.65	2.9	2.05	2.75	2.75
16	3.7	3.2	5.2	5.8	7.3	5.3	4.0	2.6	2.8	2.05	2.7	2.7
17	3.8	3.25	5.0	5.6	6.9	5.3	3.7	2.7	2.75	2.2	2.7	2.75
18	3.5	3.35	7.1	5.3	6.5	5.4	3.55	2.45	2.9	2.5	2.7	2.5
19	3.35	3.35	8.2	5.2	6.3	5.3	3.35	2.61	2.7	4.1	2.7	2.65
20	3.3	3.15	8.0	4.9	6.4	5.1	3.4	3.3	2.55	4.3	2.75	2.6
21	3.15	3.3	8.6	5.2	5.9	5.2	3.3	3.1	2.5	4.0	2.65	2.6
22	3.2	3.35	9.2	5.3	5.6	5.2	3.2	2.75	2.5	3.85	2.7	2.6
23	3.05	3.5	10.2	5.1	5.3	5.3	3.1	2.7	2.5	3.6	2.75	2.6
24	3.1	3.35	10.8	4.9	5.1	5.2	3.1	2.7	2.5	2.45	2.7	2.65
25	3.15	3.3	11.1	4.7	4.7	5.0	3.1	2.65	2.3	3.4	2.7	2.3
26	3.25	3.5	11.4	4.5	4.75	4.7	2.8	3.1	2.5	3.35	2.5	2.65
27	3.2	3.4	11.4	4.5	4.7	4.6	2.8	3.1	2.45	3.2	2.5	2.8
28	3.1	3.65	11.0	4.45	4.6	4.55	2.85	3.3	2.4	3.2	2.75	2.6
29	3.2	.....	11.0	4.35	4.6	4.4	3.1	3.3	2.3	3.05	3.15	3.05
30	3.0	.....	10.9	4.1	4.5	4.2	3.1	3.0	2.35	3.05	3.1	4.6
31	3.0	.....	10.7	.....	4.5	.....	2.95	2.85	.....	2.95	.....	3.5

[1] Gage heights interpolated.

Note—Ice conditions uncertain during January and February. Partial ice conditions during December. Discharge applied as for open channel.

Daily gage height, in feet, of Rock River at Rockton, Ill., for 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Oct.	Nov.	Dec.
1906.										
1	3.3	5.45	8.8	8.7	4.15	3.15	3.3	1.1	1.5	3.25
2	2.95	5.0	8.8	8.45	4.15	3.0	3.2	1.4	1.6	3.0
3	2.85	5.72	11.15	7.95	4.1	2.9	3.15	1.3	1.4	2.85
4	3.9	5.45	10.8	7.0	4.1	2.45	3.05	1.2	1.5	2.7
5	4.57	6.75	10.0	6.25	4.0	2.8	3.0	1.1	1.45	2.6
6	4.9	6.9	10.25	6.15	3.9	2.9	2.9	1.05	1.55	2.9
7	4.9	5.75	9.85	6.1	3.95	2.8	2.85	1.4	1.55	2.65
8	5.6	7.15	9.45	6.15	3.85	2.8	2.7	1.15	1.5	2.25
9	6.25	6.5	9.25	6.65	3.8	2.6	2.7	1.1	1.4	2.4
10	6.0	5.45	8.75	7.0	3.7	2.6	2.6	1.0	1.4	2.4
11	4.85	5.75	8.4	7.0	3.6	2.55	2.6	1.1	1.4	2.35
12	4.0	5.7	6.8	6.45	3.6	2.7	2.5	1.1	1.35	2.35
13	3.5	4.7	6.05	6.8	3.4	2.6	2.4	1.1	1.45	2.3
14	3.1	4.7	6.2	6.4	3.5	2.5	2.45	1.1	1.4	2.3
15	3.4	5.88	6.3	6.15	3.5	2.5	2.5	1.0	1.4	2.3
16	8.4	5.7	6.0	6.25	3.45	2.5	2.45	.95	1.3	2.0
17	7.25	5.45	6.25	6.05	3.2	2.3	2.5	1.0	1.15	2.0
18	7.1	5.1	5.61	5.9	3.15	2.3	2.4	1.0	1.3	2.0
19	7.3	4.3	5.31	5.75	3.0	2.45	2.3	.95	1.1	2.15
20	7.3	5.0	5.0	5.6	2.95	2.35	2.4	1.0	1.3	2.2
21	9.62	9.4	4.75	5.4	3.05	2.7	.....	1.25	1.3	2.0
22	9.5	9.1	4.3	5.35	2.9	2.6	.....	1.25	1.75	2.0
23	7.85	8.83	4.5	5.25	2.9	2.7	.....	1.3	1.95	2.0
24	8.7	9.25	4.4	5.0	2.9	2.65	.....	1.25	1.75	2.0
25	9.3	10.7	4.4	4.8	2.85	2.6	.....	1.3	1.8	1.5
26	9.5	9.85	4.65	4.7	2.9	2.75	.....	1.35	2.4	2.5
27	9.15	9.4	8.21	4.55	3.1	2.6	.....	1.4	3.4	1.5
28	8.3	9.25	8.3	4.53	3.4	2.5	.....	1.5	3.9	1.5
29	7.8	.....	8.7	4.5	3.2	3.1	.....	1.6	3.85	1.65
30	7.1	.....	8.8	4.21	3.6	3.3	.....	1.6	3.65	1.45
31	6.05	.....	8.75	.....	3.5	.....	.....	1.7	.....	3.01

Note.—Ice conditions January 5 to 10 and February 8 to 20; slight ice conditions during December. Gage heights are to water surface. This station was temporarily discontinued from July 21 to September 30.

Mean daily gage height, in feet, of Rock River at near Rockton, Ill., for 1907.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1907.												
1	4.2	.....	2.7	6.3	3.5	3.0	2.2	3.3	2.1	.....	1.95	2.0
2	3.7	.....	2.6	6.0	3.5	2.9	2.15	3.0	2.05	.....	1.95	1.9
3	3.6	.....	2.5	5.1	3.25	2.7	2.1	2.85	2.1	.....	1.75	1.75
4	4.4	.....	2.5	4.8	3.35	2.55	2.0	2.8	2.0	.....	1.85	1.8
5	4.25	.....	2.5	4.75	3.0	3.1	3.6	2.8	1.9	.....	2.0	1.85
6	4.05	.....	2.65	4.65	2.9	3.15	3.4	2.6	1.8	3.85	1.85	1.95
7	4.05	.....	2.5	4.60	2.8	3.7	3.2	2.5	1.75	3.5	1.75	1.7
8	4.9	.....	2.4	4.90	2.8	4.1	3.0	2.4	1.7	3.4	1.8	1.75
9	4.3	.....	2.3	5.25	2.8	4.7	3.15	2.55	1.65	3.2	1.75	1.85
10	4.15	.....	2.3	5.3	2.4	4.5	3.1	2.5	1.8	3.0	1.65	1.9
11	3.9	.....	2.3	5.2	2.5	4.2	2.65	2.35	1.7	2.85	1.6	2.0
12	3.5	.....	2.3	4.95	2.3	4.0	4.3	2.2	1.8	2.85	1.7	2.0
13	3.4	.....	2.6	4.7	2.1	4.1	4.2	2.15	1.75	2.8	1.7	1.9
14	2.95	.....	2.5	4.6	1.8	4.0	4.15	2.1	1.65	2.6	1.45	1.7
15	2.95	.....	3.5	4.45	2.1	3.9	3.7	2.0	1.55	2.55	1.7	1.75
16	2.3	.....	3.3	4.3	2.0	3.65	3.25	2.0	1.25	2.6	1.6	1.8
17	2.3	.....	3.2	4.1	2.1	3.45	3.2	2.5	1.45	2.5	1.55	1.75
18	2.3	3.7	3.2	4.1	2.15	3.2	3.0	3.5	2.55	2.45	1.6	1.8
19	7.1	4.0	3.15	4.1	2.0	3.5	2.95	3.2	3.6	2.45	1.55	1.8
20	8.0	4.1	3.15	3.85	1.9	3.3	2.75	3.15	4.55	2.5	1.6	1.7
21	4.7	4.3	3.1	3.8	1.9	3.1	2.6	3.2	5.25	2.3	1.7	1.6
22	5.7	4.4	3.1	3.5	1.9	2.85	3.3	3.2	5.35	2.2	2.0	1.4
23	6.8	5.0	3.15	3.35	2.2	2.85	4.5	3.25	5.35	2.1	2.0	1.65
24	7.5	4.35	3.35	3.4	2.6	2.8	4.8	3.15	4.8	2.0	2.3	1.7
25	7.0	3.9	3.4	3.4	2.8	2.9	5.5	2.8	3.7	2.0	2.3	1.7
26	6.3	3.5	3.35	3.25	3.3	2.95	5.85	2.5	3.15	2.0	2.1	1.75
27	6.45	3.0	3.5	3.0	3.45	2.75	5.8	2.5	2.9	1.9	2.0	1.7
28	6.1	2.9	3.5	3.0	3.6	2.4	5.3	2.45	3.3	2.0	2.0	1.8
29	(1)	(1)	3.9	3.05	3.3	2.5	5.0	2.25	4.5	1.9	2.1	1.85
30	.....	.....	5.2	3.28	3.2	2.3	3.65	2.25	4.8	1.9	2.1	1.9
31	.....	.....	5.65	.....	3.0	.....	3.4	2.2	.....	1.9	.....	2.0

[1] Frozen.

Rating Table for Rock River, Ill., for 1904-1906.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-ft.
1.00	500	2.10	1,470	3.20	3,105	4.60	5,760
1.10	560	2.20	1,600	3.30	3,280	4.80	6,180
1.20	624	2.30	1,740	3.40	3,455	5.00	6,620
1.30	692	2.40	1,880	3.50	3,635	5.20	7,070
1.40	764	2.50	2,025	3.60	3,815	5.40	7,540
1.50	840	2.60	2,170	3.70	3,995	5.60	8,020
1.60	925	2.70	2,320	3.80	4,180	5.80	8,520
1.70	1,020	2.80	2,470	3.90	4,365	6.00	9,020
1.80	1,122	2.90	2,620	4.00	4,555		
1.90	1,234	3.00	2,775	4.20	4,940		
2.00	1,350	3.10	2,935	4.40	5,345		

Note.—The above table is applicable only for open-channel conditions. It is based on discharge measurements made during 1904-1906. It is well defined between gage heights 2.4 feet and 6 feet. The table has been extended beyond these limits, being on one measurement at 13.32 feet. Above gage height 5.6 feet the rating curve is a tangent, the difference being 250 per tenth. Below gage height 2 feet the rating is approximate.

Discharge measurements of Rock River at Rockton, Ill., in 1903, 1904, 1905 and 1906.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1903.		Feet.	Sq. feet.	Feet per sec.	Feet.	Sec.-feet.
May 13	L. R. Stockman	.....	.....	.....	2.90	2,529
June 30	A. C. Lootz	296	547	2.74	2.30	1,501
August 18	L. R. Stockman	490	1,352	3.41	4.07	4,611
September 4	F. W. Hanna	.....	1,352	3.41	4.08	4,607
October 9	do	504	1,998	3.74	5.35	7,464
November 9	do	453	831	[1]3.46	2.85	2,874
December 10[2]	do	367	743	3.21	2.60	2,384
1904.						
January 16[2]	F. W. Hanna	380	662	2.25	2.90	1,487
March 14	do	509	4,031	2.77	9.30	11,180
March 25	do	509	5,744	4.34	12.32	24,910
April 28	do	504	2,361	3.90	5.91	9,212
June 23	do	378	660	3.18	2.50	2,099
July 7	do	389	645	2.93	2.38	1,889
August 30	do	381	674	3.02	2.45	2,034
September 23	do	408	739	3.19	2.65	2,355
October 26	do	426	759	3.13	2.70	2,372
November 9	do	397	695	3.09	2.50	2,149
1905.						
March 23	M. S. Brennan	516	4,650	3.82	10.37	17,770
April 29	do	503	1,524	3.52	4.42	5,361
June 29	do	503	1,530	3.27	4.44	5,152
August 26	do	482	1,012	3.28	3.20	3,324
September 15	do	460	860	3.24	2.88	2,783
1906.						
January 31	M. S. Breenan	503	2,390	.....	5.79	8,240
February 24	do	510	4,300	.....	9.85	16,000
February 25	do	510	4,740	.....	10.55	18,600
February 27	do	510	4,130	.....	9.36	15,400
February 27	do	510	4,180	.....	9.45	16,500
February 28	do	510	4,000	.....	9.13	14,900
May 3	do	494	1,430	.....	4.10	4,570

Note—Measurements January 31 to February 28, were slightly affected by ice conditions below the gaging section.

Discharge measurements of Rock River near Rockton, Ill., under ice conditions.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gage height.	Discharge.
1908.		*Feet.*	*Sq. ft.*	*Feet per sec.*	*Feet. wat. sur.*	*Sec.-ft.*
[1]Feb. 5	G. A. Gray	508	1099	1.80	2.85	1,977

[1] No snow. Average thickness of ice 0.8 of a foot.
February 5. Average thickness of ice 0.8 of a foot.
February 7. Average thickness of ice 0.7 of a foot.
February 11. Average thickness of ice 1.0 of a foot.
February 12. Ice went out.

Monthly discharge of Rock River at Rockton, Illinois.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum	Mean.	Depth in inches.	Second-feet per square mile.
1903.					
July	11,990	2,015	5,584	1.05	0.91
August 1 and 9-31	.....	.....	3,880	.56	.63
September	8,990	3,815	5,578	1.02	.91
October	8,990	2,985	4,786	.90	.78
November	3,455	2,015	2,712	.49	.44
December	4,180	2,160	2,795	.52	.45
1904.					
January[1]	3,260	2,170	2,747	0.514	0.446
February[1]	9,270	2,470	4,762	.835	.774
March[1]	27,100	4,180	17,220	3.23	2.80
April	20,640	5,828	10,810	1.96	1.76
May	6,598	4,162	5,405	1.01	.879
June	3,959	1,535	2,437	.441	.395
July	2,025	1,070	1,570	.294	.255
August	2,935	860	1,471	.276	.239
September	4,940	1,470	2,344	.425	.381
October	5,560	2,098	3,058	.573	.497
November	2,245	1,600	1,847	.335	.300
December	6,955	1,535	2,514	.472	.409
The year	27,100	860	4,682	10.37	.761

[1] Daily discharges for January, February and March applied as for open channel.

Estimated monthly discharge of Rock River at Rockton, Illinois, for 1905.

Month.	Discharge in Second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1905.					
January	5,655	2,775	3,716	0.696	0.604
February	3,905	2,935	3,250	.560	.528
March	22,520	4,555	12,890	2.48	2.10
April	19,270	4,745	10,000	1.82	1.63
May	12,270	3,455	6,748	1.27	1.10
June	7,540	4,940	6,491	1.18	1.03
July	5,140	2,470	3,916	.734	0.637
August	3,280	1,952	2,538	.476	.413
September	4,272	1,740	2,642	.480	.430
October	5,140	1,240	2,411	.452	.392
November	3,020	2,025	2,463	.446	.400
December	5,760	1,740	2,722	.511	.443
The year	27,520	1,240	4,986	11.04	.811
1906.					
January	18,100	2,540	9,620	1.56	1.83
February	19,000	4,000	9,760	1.59	1.66
March	20,300	5,140	11,800	1.92	2.21
April	15,800	4,060	9,160	1.49	1.66
May	4,840	2,540	3,590	.584	.67
June	3,280	1,740	2,280	.371	.41
July 1-20	3,280	1,740	2,330	.379	.28
October	1,020	472	641	.104	.12
November	4,360	560	1,280	.208	.23
December	3,190	802	1,740	.283	.33

Note.—Values are rated as follows: January and March, good; February and October, approximate; April to July, excellent; November and December, fair. Discharge for ice periods corrected.

FALL OF THE RIVER.

The lack of that variation in the bed of the river which characterizes the rivers of Northern Wisconsin results in fewer rapids and reduced gradient. The average fall of the river between Horicon and the state line is only a little over one foot to the mile, the largest concentrations being at Hustisford, Watertown, Jefferson, Janesville, and Beloit. The following table gives the profile of the river in detail:

Profile of Rock River from state line to head waters.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
				Feet.	Feet.	Feet.
1	Illinois—State line	0.0	.....	731.	.....	.....
2	Beloit Dam, below dam	0.8	0.8	732.	1.0	1.2
3	Beloit Dam, above dam	0.8	0.0	741.	9.	.....
4	Afton	10.8	10.0	747.	6.	0.6
5	Monterey Dam—Janesville, below dam	15.8	5.	752.	5.	1.0
6	Monterey Dam—Janesville, above dam	15.8	0.0	761.	10.	.....
7	Ford Dam—Janesville, below dam	17.8	2.	762.	1.	0.5
8	Ford Dam—Janesville, above dam	17.8	0.0	769.5	7.5	.....
9	Catfish River, mouth	28.3	10.5	772.	2.5	.25
10	Indian Ford dam, below dam	30.0	1.7	773.5	1.5	0.9
11	Indian Ford dam, above dam	30.0	0.0	778.	4.5	.....
12	Lake Koshkonong—, foot of	36.5	6.5	779.	1.0	0.15
13	Lake Koshkonong—, head of	42.5	6.0	779.	0.0	.....
14	Fort Atkinson	48.5	6.0	780.	1.0	0.16
15	Jefferson Dam, below dam	56.5	8.0	782.	2.0	.25
16	Jefferson Dam, above dam	56.5	0.0	787.	5.0	.....
17	Lower Watertown Dam, below dam	71.5	15.	797.4	10.4	.7
18	Lower Watertown Dam crest, above dam	71.5	0.0	803.2	10.8	.....
19	Upper Watertown Dam, below dam	74.0	2.5	811.1	2.9	1.1
20	Upper Watertown Dam, crest dam	74.0	0.0	818.3	7.2	.....
21	C., M. & St. P. Ry. Crossing, 2 miles east of Watertown	75.3	1.3	819.0	.7	.5
22	E. Quarter Stake, S. 27, T. 9, N. R., 16 E.	85.8	10.5	834.	15.	1.5
23	Mouth of Wildcat Creek near Hustisford	120.	34.2	846.	12.	.4
24	Hustisford Dam, below dam	120.2	0.2	851.5	5.5	27.5
25	Hustisford Dam, crest dam	120.2	0.0	857.3	5.8	.....
26	Horicon—Lake St. Bridge	129.0	8.8	858.5	1.2	.13
27	Mayville Ry. Bridge, E. Branch	142.	13.0	900.	41.5	3.2
28	Theresa Ry. Bridge, E. Branch	152.	10.	933.	33.	3.3
29	Chester, West Branch of Rock River	144.	.....	833.	.....	.....

Authority 1-16 U. S. Engrs.; 17 29, Wis. Geol. Survey; 21 C., M. & St. P. Ry.; 23 29, L. S. Smith.

Description of Water Powers.

Taking the water powers in the order of their occurrence from the source southward. Above Horicon the river divides into the east and west branches. Dams are located at Kekoska and Mayville and, until ten years ago, also at Theresa. On the West Branch a dam is located at Waupun. These dams are quite fully described in the tabulation of tributaries.

Horicon.—The first large power site is located at Horicon but as stated above it has not been developed or used since 1868. A dam 200 feet long would develop a head of 10 feet, besides creating a reservoir of over 50 square miles. For economic reasons as explained elsewhere it is extremely unlikely that this power will ever be again developed.

Hustisford.—Between Horicon and Watertown the river has a fall of 61 feet. In this section the river runs comparatively close to the eastern limit of its valley. But 10 miles above, accumulations of drift have turned the river from a southern to a northwestly direction until Watertown is reached. The sinuosity of the stream is shown by the fact that while the air line distance between Horicon and Watertown is only 20 miles, by river it is 57 miles. The channel is partly in the dirft and partly in the rock where it has succeeded in cutting through the former.

At Hustisford, a rough rock and timber dam about 6 feet high and 200 feet long was constructed as early as 1842 at the head of the first limestone rapids. Two mills take their power from this dam by means of a race about 1,300 feet long located on the right or west bank, but with unequal heads, because of the rapids in the river below the dam.

Originally the water power was owned by Fred Dehne and Sons but later their mill and the right to use 875 inches of water under a 7 foot head was sold to J. F. W. Koch. Another mill was built 800 feet farther below and the race extended to the new site. In August, 1906, when a survey of these powers was made by the writer, the Koch Mill had a head of 7.6 feet and the Dehne Mill 10.7 feet. The Koch Mill had a 40 and a 48 inch Laffel turbine used for manufacturing flour and grinding feed.

The Dehne Mill has three turbines of 30, 40, and 48 inch diameter all used to run a flour, saw, planing mill, and cheese box factory. This dam backs the water up to Horicon marsh.

In case the Horicon Marsh Drainage project is authorized by the court, this dam will have to be removed. The dam at present is in great need of reconstruction, a large part of the dam having been carried away by a recent freshet and simply replaced by earth. Between Hustisford and the railroad crossing near Ixonia the river is bordered for a long stretch by low lands and marshes and the total fall in this section of 45 miles is only 12 feet.

Pipersville.—A mile east of Pipersville, however, the valley narrows to a few rods with steep banks on either side. It seems certain that a head of ten or more feet could be cheaply developed at this point, though considerable flooding might result.

Watertown Powers.—There are two dams located in the City of Watertown; the lower, a masonry dam, located a few blocks above the Chicago, Milwaukee and St. Paul Railroad bridge and the upper dam, one and one-half miles above this. The bed of the river at both dams and probably for the entire distance between, is in the Trenton limestone. The upper dam, usually called the "Rough and Ready" dam, is built of timber with masonry abutments. It is 250 feet long and develops a head of 9 feet. One 45 and one 55 inch turbine are installed, rated at 225 horse-power. This power is owned by the Watertown Electric Company and is used for electric light and power. As the left bank is low the present head represents the maximum head which can be developed. Indeed there have been some complaints of illegal flooding at times of high water. The dam is in a fair state of repair. The legislature of 1906–07 granted the owners the right to raise the crest of dam 2 feet, provided all payment should be first made for all damage so caused.

The lower dam was reconstructed three or four years ago, the present concrete dam replacing an old style timber structure. The present dam is 250 feet long and furnishes a head of about 10 feet. This head cannot be increased as the dam backs the water to the dam above. The lower dam furnishes power to four different concerns two on each bank. On the right bank are located the Bee-hive and Box Factory owned by G. B. Lewis Company and the Globe Milling Company with installations of two 30 inch and two 40 inch turbines respectively.

On the left bank are located the R. P. Koenig Company flour mill and the A. R. Weins Brush Company factory with an installation of 60 inch and 30 inch turbine respectively.

The mills run 18 and the factories 10 hours per day. The owners report that for 8 or 9 months in the year the turbines develop their full power but that during the remainder of the year steam power has to be to a large extent substituted. For this purpose the above four mills have the following steam power:— The Globe Milling Company 200 horse-power; R. P. Koenig Company 85 horse-power; G. B. Lewis Company 225 horse-power, and the A. R. Weins Company 25 horse-power.

The head on the turbines is reported to vary between 12 and 6 feet. With water to the crest of the dam the head is 10 feet. Complaints of illegal flooding by this dam have been made since the reconstruction of the dam.

Watertown is a growing city of 9,000 inhabitants. It is a trading center for a large and rich agricultural region. The city is on the main line of the Chicago, Milwaukee and St. Paul Railroad between Milwaukee and St. Paul and also on the Madison branch of the same railroad. The city is also served by the Chicago and North-Western Railroad between Beloit and Green Bay. Between Watertown and Lake Koshkonong, a distance of 29 miles, the river flows almost due south and with reduced windings. The river varies in width from 150 to 250 feet wide, with banks sloping gently back to a height of from 10 to 20 feet.

The total fall between the foot of the lower Watertown dam and Lake Koshkonong is only 18 feet of which only a third is used.

Boomer's Dam.—One of the early charters for dams was that granted for "Boomer's" dam about one mile south of Watertown. The charter grants the right to a six foot head. At this point the banks are fairly high and no serious flooding resulted. The dam was allowed to decay many years ago but while standing, the power was used to run a small flour mill. Were it not for the cost of maintaining a dam here and the great fluctuations in the amount of water, especially the latter, this power, because of its nearness to Watertown, would be decidedly valuable. No tributary of importance joins the river between Watertown and Jefferson.

Jefferson Dam.—This dam was built about 1842 by logs framed together with a rubble stone filling about 50 feet in width. The east end has a masonry wall 75 feet long and a little higher than the highest stage of the river. Adjoining this wall is a sluice gate 30 feet long, and then a crest of 150 feet longer. The head on the dam varies between 4 and 6 feet with an average of 4½. The power is used for running two

mills, the Jefferson Flouring Mills owned by David Johnson and the Jefferson Woolen Mill owned by Mr. Stoppenbach, the former owning five-eighths and the latter three-eighths of the flowage. Both mills are located on the right (west) bank, the woolen mill taking water direct from the dam while the flour mills are located on a mill race about 500 feet long. The flour mill has an installation of four 56 inch turbines rated at 160 horse-power, and the woolen mill two 56 inch turbines, rated at 80 horse-power. The total actual horse-power utilized is reported to be 150 for 10 hours per day which is obtained throughout the year, except for a few days in the spring when prevented by back water.

The charter authorizes a head of 4 feet above high water so that it would seem possible to increase the present head by about 3 feet.

About 1,000 feet below this dam the Crawfish River joins the Rock River from the west increasing the tributary drainage area from 1,100 to 1,890 square miles. Below the junction the river banks are lower. This compelled the building of the dam above the mouth in order not to overflow too much land.

The river falls only 3 feet between the foot of Jefferson dam and Lake Koshkonong and flows through a wide, and, for much of the way, a marsh bordered valley. At Fort Atkinson, 8 miles below Jefferson, Bark River enters from the east increasing the drainage area from 1,920 to 2.250 square miles.

Between the foot of Lake Koshkonong and the mouth of the Catfish or Yahara River, Rock River breaks through the Kettle Range but not without increasing its gradient. The total fall from Lake Koshkonong to the state line a distance of 36.5 miles is 48 feet, 34 feet of which has been developed by four dams. The entire length is characterized by moderately high banks and the absence of marshes.

Indian Ford Dam.—This dam is located about six miles below the foot of Lake Koshkonong and until 1905 was used principally to control the flow in the interests of the water powers below Rockton. The pondage proving inadequate to the demands made upon it by the lower mill owners, the property was sold to Mr. Pliny Norcross, the present owner. The head varies between 6.5 to 4 feet with an average of 6 feet. Part of the power is used to run a flour mill at the dam. This power is conducted electrically to Janesville and used to augment the city electric plant. Three 48 inch turbines are installed used with full gate at night, and from ¼ to ½ opening during

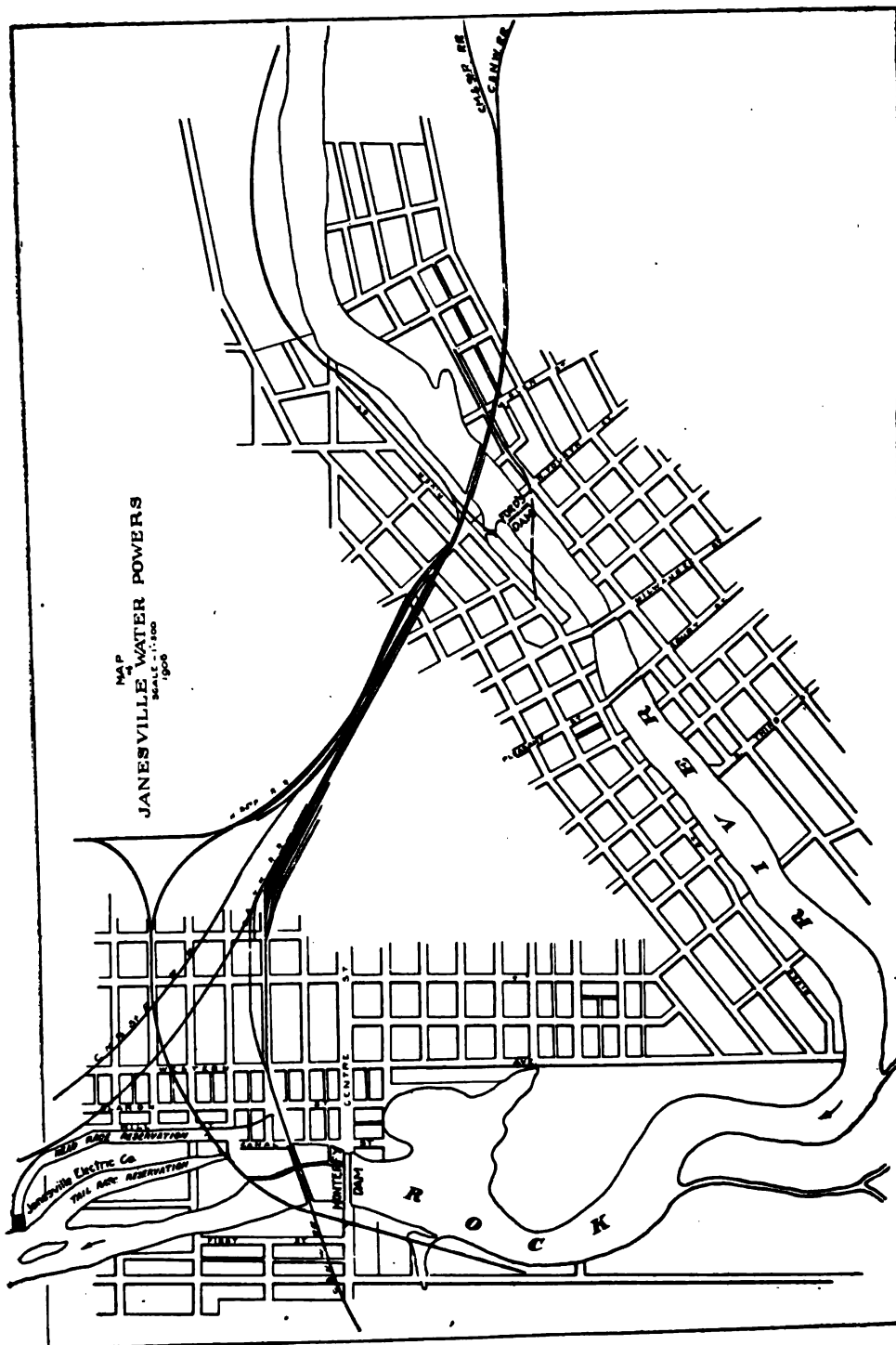

Fig. 16.—Location of Janesville dams.

the day. Attention has been called elsewhere to the fact that this dam could be raised much higher, except for the flooding that would result around the shores of Lake Koshkonong and above. Even a raise of a few feet would greatly assist the water-powers below in increasing the pondage for use in time of low water.

Janesville Powers.—Janesville, a city of nearly 14,000 population, is the natural trading center of Rock County. The city enjoys exceptional railroad facilities. Both the Chicago, Milwaukee and St. Paul and the Chicago and Northwestern Railroads have north and south as well as east and west lines intersecting at Janesville. Fig. 16 shows clearly the location of the Janesville dams.

Rock River makes an abrupt turn in the city of Janesville from a south-easterly to a due west direction. In the accompanying map it will be seen that there are two dams; one near the heart of the city and the other about one and one-half miles below, near the limit of the city. The upper dam, known as Ford's dam, has a head of 8 feet and is shown in Plate LI.

When the original improvements were made at the upper or Ford dam, the power was estimated to be 13,309 "inches" of water under head of 4 feet, which was the original height of the dam. There have been a number of changes in ownership during recent years due to a concentration of same in the Janesville Electric Company but at present the water at Ford's dam in Janesville is owned as follows:

First Water	Janesville Electric Co	4,100	sq. in.
	H. & V. P. Richardson	400	" "
	Blodgett Milling Co.	200	" "
Second Water	H. & V. P. Richardson	200	" "
Third Water	Janesville Electric Co	550	" "
Fourth Water	Janesville Sash and Door Co	209	" "
Fifth Water	Blodgett Milling Co	1,000	" "
Sixth Water	Janesville Electric Co	500	" "
Seventh Water	Janesville Electric Co	50	" "
Eight Water	Janesville Electric Co	740	" "
Ninth Water	Janesville Electric Co	350	" "
Tenth Water	Janesville Electric Co	400	" "
Eleventh Water	H. & V. P. Richardson	200	" "
	Janesville Electric Co	66⅔	" "
Twelfth Water	Blodgett Milling Co	500	" "
	Janesville Electric Co	166⅔	" "
Thirteenth Water	Janesville Electric Co	1,333⅓	" "
Fourteenth Water	Janesville Electric Co	100	" "
Fifteenth Water	Janesville Electric Co	33⅓	" "
Sixteenth Water	Janesville Sash & Door Co	250	" "
	Janesville Electric Co	83⅓	" "
Seventeenth Water	Janesville Electric Co	1,599⅔	" "

500 sq. in. of water belonging to Thomas Tappin has lapsed.

FORDS DAM. ROCK RIVER AT JANESVILLE.
High water. Head, 8 feet.

FORDS DAM. ROCK RIVER AT JANESVILLE.
Low water.

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This measurement is in square inches of water under a 4 ft. head and is reduced to the amount of water to give the same power under a 7 ft. head, for the actual measurement. One square inch of water under the 4 ft. head is figured as equal to 6.68 cu. ft. of water per minute.

Engineers familiar with the river state that the normal flow of 8 months of the year is 750 second feet and that the ordinary low water flow is only 200 second feet. An explanation for so small a minimum flow is, that this is due to the fact that the river is flowing below Indian Ford in an old filled valley, the gravel having been found to extend to a depth of 300 feet. It seems reasonable to suppose that a large proportion of the total waters discharged are found in this under flow, and that the apparent river flow suffers most of the fluctuations following precipitation thus causing an increased ratio between the waters discharged by the river in the high and low water months of each year.

It will be noted that the ownership of the water power is in the hands of four companies, two of which, the Janesville Electric Company and the New Doty Manufacturing Company, are located at the dam on the right and left banks respectively. The remaining water power users, the Jeffris Company and the Blodgett Milling Company, are located on a race about 1,500 feet long adjacent to the right (west) bank of the river. These plants will now be briefly described:—

The Janesville Electric plant was fully described in an article prepared by Professor D. C. Jackson and published in the August number of the Electric Age 1906. The following is largely condensed from this article, although a personal examination of this dam was made.

The Janesville Electric Company secured the greater part of the water rights at the Ford dam by purchasing a cotton factory, which was torn down and the present substantial plant with its re-enforced concrete penstocks was completed in 1906. The water wheel equipment consists of 4 new wheels rated at 148 horse-power each, and 2 old wheels rated at 100 horse-power each. The four are arranged to drive upon a main horizontal shaft while the two drive an independent shaft.

The same company owns power plants also at the Monterey and Fulton dams.

The New Doty Manufacturing Company have one 50 inch turbine rated at 56 horse-power used to run a Machine Shop and Foundry. The company has no auxiliary steam power. A statement of its water rights will be found elsewhere.

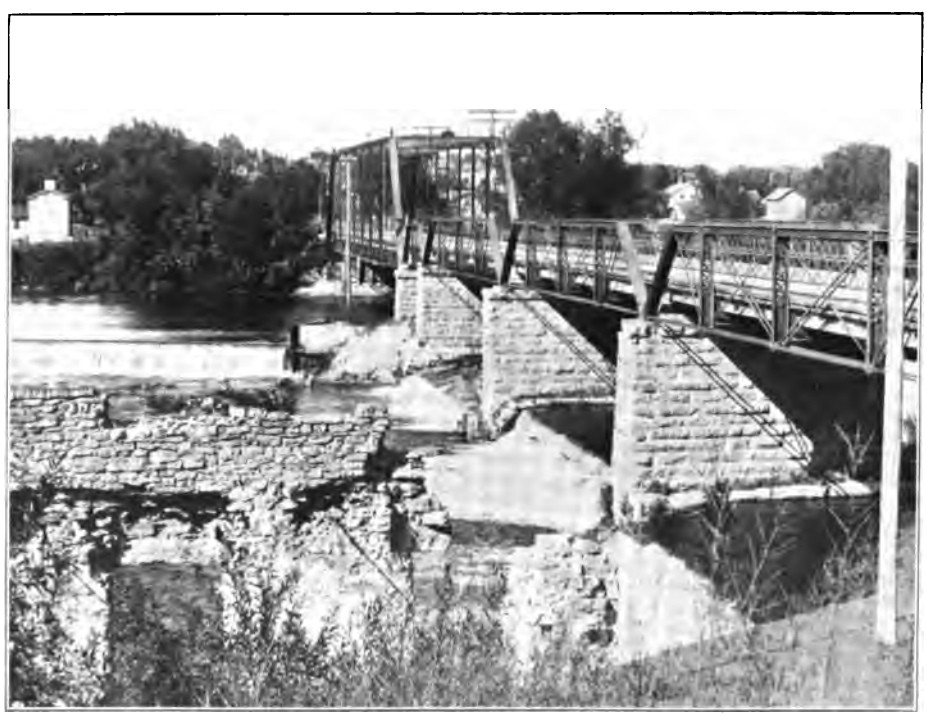
The Blodgett Milling Company have three old style 60 inch turbines rated at 295 horse-power but whose actual horse-power as employed is about 65 horse-power used in the milling of rye and buckwheat flour. The mill runs 24 hours per day. The Company have one steam engine of 100 and one of 150 horse-power.

The Jeffris Company manufacture sash doors and interior finishings and for this purpose have one 48 inch turbine rated at 33 horse-power as well as one steam engine of 40 horse-power. The Mill formerly ran ten hours daily, at the present time it is idle. A statement of the water rights of this company appears elsewhere.

Monterey Dam.—This dam is located in the southern part of Janesville near Center Street. Two views of the dam are shown in Plate LII. It is chiefly of timber construction, extending under Center Street from the left bank and then continuing down stream, connecting with the side of the mill race. The latter is nearly a half mile long. While the head at the dam is only 6 feet, at the end of the race it is about 9½ feet. The left bank is steep and bluffy, while the right bank stretches away in a broad flat, affording fine opportunities for utilizing the power. There has been a good deal of litigation in the past in connection with the ownership of the power. At present the water at Monterey plant is owned as follows:—[1]

Owners.	Water rights.	Square inches of water.
Janesville Woolen Mills	First	775
Janesville Electric Company	Second	725
Janesville Woolen Mills	Third	200
Bower City Light and Power Company	Fourth	400
Janesville Woolen Mills	Fifth	425
Janesville Electric Company	Sixth	450
Chicago and Northwestern Railroad Company	Seventh	200
Janesville Electric Company	Eighth	4,504
Bower City Light and Power Company	Ninth	200
Janesville Woolen Mills	Tenth	600
Bower City Light and Power Company	Eleventh	200
Janesville Electric Company	Twelfth	200
Janesville Electric Co. own all of the residue of said water power.		

[1] Authority is William B. Jackson, M. E



MONTEREY DAM, JANESVILLE. ROCK RIVER.
Head, 9½ feet at Plant.

In case the Horicon Marsh Drainage project is authorized by the court, this dam will have to be removed. The dam at present is in great need of reconstruction, a large part of the dam having been carried away by a recent freshet and simply replaced by earth. Between Hustisford and the railroad crossing near Ixonia the river is bordered for a long stretch by low lands and marshes and the total fall in this section of 45 miles is only 12 feet.

Pipersville.—A mile east of Pipersville, however, the valley narrows to a few rods with steep banks on either side. It seems certain that a head of ten or more feet could be cheaply developed at this point, though considerable flooding might result.

Watertown Powers.—There are two dams located in the City of Watertown; the lower, a masonry dam, located a few blocks above the Chicago, Milwaukee and St. Paul Railroad bridge and the upper dam, one and one-half miles above this. The bed of the river at both dams and probably for the entire distance between, is in the Trenton limestone. The upper dam, usually called the "Rough and Ready" dam, is built of timber with masonry abutments. It is 250 feet long and develops a head of 9 feet. One 45 and one 55 inch turbine are installed, rated at 225 horse-power. This power is owned by the Watertown Electric Company and is used for electric light and power. As the left bank is low the present head represents the maximum head which can be developed. Indeed there have been some complaints of illegal flooding at times of high water. The dam is in a fair state of repair. The legislature of 1906–07 granted the owners the right to raise the crest of dam 2 feet, provided all payment should be first made for all damage so caused.

The lower dam was reconstructed three or four years ago, the present concrete dam replacing an old style timber structure. The present dam is 250 feet long and furnishes a head of about 10 feet. This head cannot be increased as the dam backs the water to the dam above. The lower dam furnishes power to four different concerns two on each bank. On the right bank are located the Bee-hive and Box Factory owned by G. B. Lewis Company and the Globe Milling Company with installations of two 30 inch and two 40 inch turbines respectively.

On the left bank are located the R. P. Koenig Company flour mill and the A. R. Weins Brush Company factory with an installation of 60 inch and 30 inch turbine respectively.

The mills run 18 and the factories 10 hours per day. The owners report that for 8 or 9 months in the year the turbines develop their full power but that during the remainder of the year steam power has to be to a large extent substituted. For this purpose the above four mills have the following steam power:— The Globe Milling Company 200 horse-power; R. P. Koenig Company 85 horse-power; G. B. Lewis Company 225 horse-power, and the A. R. Weins Company 25 horse-power.

The head on the turbines is reported to vary between 12 and 6 feet. With water to the crest of the dam the head is 10 feet. Complaints of illegal flooding by this dam have been made since the reconstruction of the dam.

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The total fall between the foot of the lower Watertown dam and Lake Koshkonong is only 18 feet of which only a third is used.

Boomer's Dam.—One of the early charters for dams was that granted for "Boomer's" dam about one mile south of Watertown. The charter grants the right to a six foot head. At this point the banks are fairly high and no serious flooding resulted. The dam was allowed to decay many years ago but while standing, the power was used to run a small flour mill. Were it not for the cost of maintaining a dam here and the great fluctuations in the amount of water, especially the latter, this power, because of its nearness to Watertown, would be decidedly valuable. No tributary of importance joins the river between Watertown and Jefferson.

Jefferson Dam.—This dam was built about 1842 by logs framed together with a rubble stone filling about 50 feet in width. The east end has a masonry wall 75 feet long and a little higher than the highest stage of the river. Adjoining this wall is a sluice gate 30 feet long, and then a crest of 150 feet longer. The head on the dam varies between 4 and 6 feet with an average of 4½. The power is used for running two

mills, the Jefferson Flouring Mills owned by David Johnson and the Jefferson Woolen Mill owned by Mr. Stoppenbach, the former owning five-eighths and the latter three-eighths of the flowage. Both mills are located on the right (west) bank, the woolen mill taking water direct from the dam while the flour mills are located on a mill race about 500 feet long. The flour mill has an installation of four 56 inch turbines rated at 160 horse-power, and the woolen mill two 56 inch turbines, rated at 80 horse-power. The total actual horse-power utilized is reported to be 150 for 10 hours per day which is obtained throughout the year, except for a few days in the spring when prevented by back water.

The charter authorizes a head of 4 feet above high water so that it would seem possible to increase the present head by about 3 feet.

About 1,000 feet below this dam the Crawfish River joins the Rock River from the west increasing the tributary drainage area from 1,100 to 1,890 square miles. Below the junction the river banks are lower. This compelled the building of the dam above the mouth in order not to overflow too much land.

The river falls only 3 feet between the foot of Jefferson dam and Lake Koshkonong and flows through a wide, and, for much of the way, a marsh bordered valley. At Fort Atkinson, 8 miles below Jefferson, Bark River enters from the east increasing the drainage area from 1,920 to 2.250 square miles.

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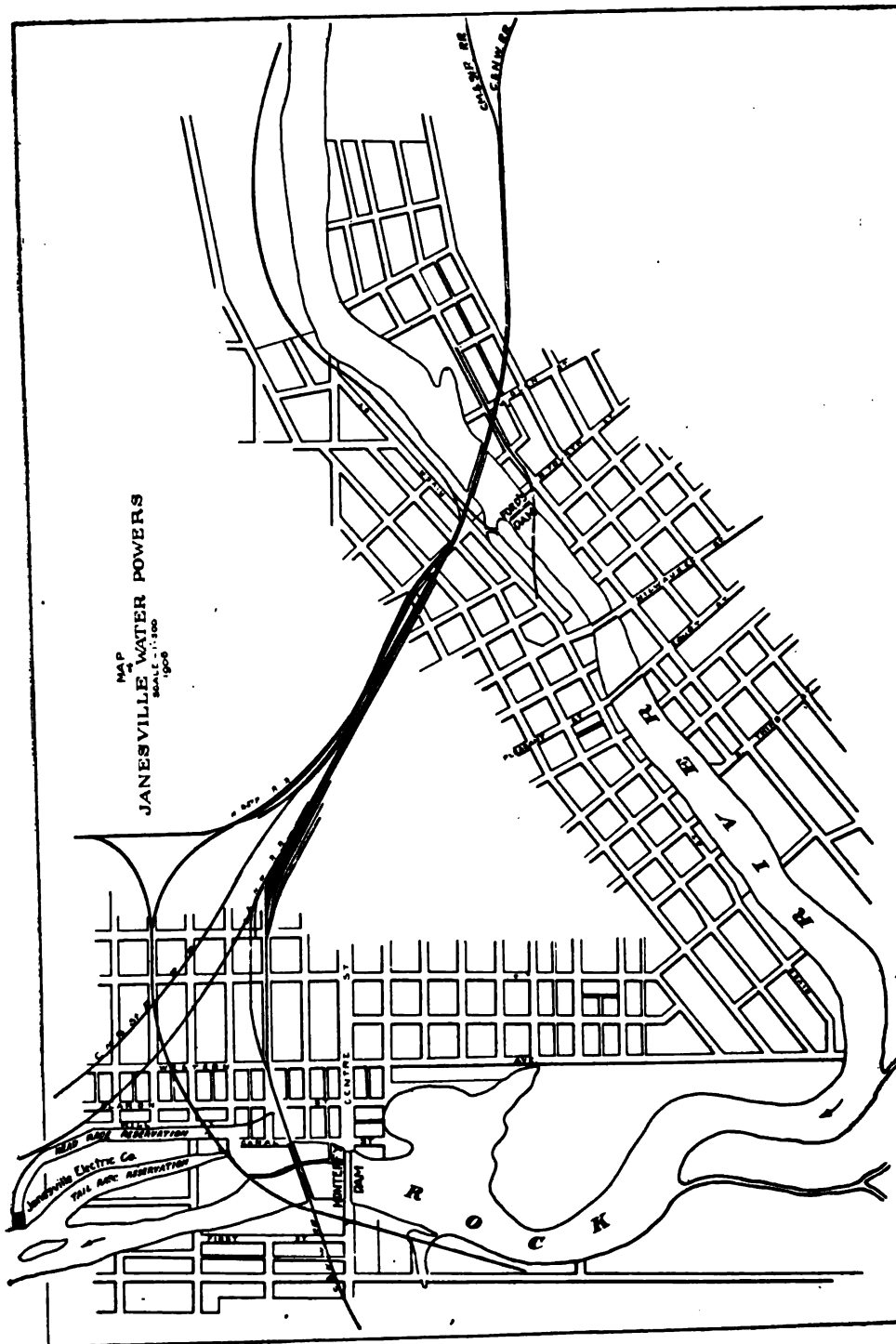

Fig. 16.—Location of Janesville dams.

There have been many shifts or sales of the water rights in the past twenty years but at present (1906) the ownership is as follows:—

	Inches.	Shares.
1. Parrett Manufacturing Company	3,900	234
2. Beloit Electric Company	3,333⅓	200
3. Beloit Water Works	2,100	126
4. Berlin Machine Works	940	56
5. C. O. Warner, Plaining	200	12
6. R. J. Dowd Knife Works	983⅓	59
7. N. B. Gaston & Sons, Scales	383⅓	23
8. Julius Flint, Star Flour Mill	500	30
9. C. H. Beasley & Company, Machine Shop	500	30
10. Beloit Iron Works, Machine Shop	500	30
Total	13,340	800

The first two companies take their power directly from the pond, but the remaining firms are located on the race and are shown on the map.

TRIBUTARIES OF THE ROCK RIVER.

For a river of its size, the tributaries of Rock River are of much less importance than would be expected. Their gradient, except in their extreme upper headwaters, is but little more than the parent river. With few exceptions, the dams have very moderate heads. In many cases, the dams have been abandoned because of the greater value of the submerged land for farms.

Oconomowoc River.

This is the first tributary of much size. It rises in Fries Lake at an elevation of about 950 feet above the sea. After a course of 30 miles, in which it traverses five of the larger lakes in Waukesha County and falls 120 feet, it joins Rock River about seven miles southeast of Watertown. In the lower ten miles of its length, its fall is only 20 feet. No dams are located in this part of the river. The following table gives the profile of the river in some detail, while a tabulated statement of the developed water powers may be found on page 317.

Profile of Oconomowoc River.

No.	Station.	Distance.		Elevation above sea level.	Descent Between Points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Source, Fries Lake	0.0	.....	950. ‡	.....	.....
2	Monchess	5.5	5.5	940.	10.	1.9
3	North Lake	9.	3.5	897.	43.	12.3
4	Outlet Lake Okauchee	11.7	2.7	880.7	16.3	6.
5	Outlet Lake Okauchee Tail Race	.....	.....	870.	10.7	.....
6	Oconomowoc Lake, Inlet	15.	3.3	861.	9.	2.7
7	Oconomowoc Lake, Outlet	16.	1.	861.	0.	0.
8	Fowler Lake	18.	2.	860.4	0.6	0.3
9	Lac La Belle, Inlet	18.2	0.2	852.	8.4	42.
10	Lac La Belle, Outlet	20.	1.8	852.	0.	0.
11	Mouth	30.	10.	830. ‡	22.	2.2

Authority: 1 and 2, United States Geological Survey topographic map. 3-10, levels run by L. S. Smith in 1898 for the Wisconsin Geological Survey.

Crawfish River.

Crawfish River has a drainage area of 790 square miles, located in the Northwestern part of the Rock River valley. For practically its entire length of 60 miles, it flows through a rich agricultural country with low banks and many marshes. Its total drainage area is 800 square miles.

At present, the only dams are located at Columbus and Danville. The tributaries of this river are more important power producers than the main river, especially Beaver Dam River.

Beaver Dam River.

This river rises in Fox Lake, near the northwest corner of Dodge County, at an elevation of 895 feet above the sea. It joins the Crawfish River at Mud Lake, near the southwest corner of same county. Its total length is 35 miles, including 8.2 miles between the outlet and inlet of Beaver Dam Lake. Between the water surface of Fox Lake and the river at the Chicago, Milwaukee and St. Paul Railway crossing, southeast of Reeseville, the river falls 112 feet, an average of 3.6 feet per mile.

The total drainage area above its mouth is approximately 310 square miles. Fox and Beaver Dam Lakes are really mill dams and cover approximately 12 square miles. They greatly assist the water power by storing up the storm waters.

The following profile was prepared from an accurate survey of the river between Fox Lake and Leipsic.

Profile of Beaver Dam River.

No.	Station.	Distance.		Elevation above sea level.	Descent between stations.	
		From source	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Source in Fox Lake	0.0	.....	895.	.....	.....
2	Fox Lake dam; crest	1.5	1.5	895.	0.0	0.0
3	Fox Lake dam; foot	.....	.....	883.	12.0	.....
4	Beaver Dam, Inlet	3.7	2.2	873.	10.0	4.6
5	Cotton Mill, Outlet of Lake; crest of dam	11.9	8.2	873.	0.0	0.0
6	Cotton Mill, Outlet of Lake; below dam	11.9	.....	863.6	9.3	.....
7	Upper Woolen Mill, above dam	12.2	.3	863.5	.1	0.3
8	Upper Woolen Mill, below dam	12.2	.....	852.4	11.1	.....
9	Lower Woolen Mill, above dam	12.6	.4	852.3	.1	0.25
10	Lower Woolen Mill, below dam	12.6	.....	844.	8.3	.....
11	Leipsic Dam, above dam	15.3	2.7	826.6	17.4	6.4
12	Leipsic Dam, below dam	15.3	.....	820.6	6.	.....
13	One half mile below Leipsic Dam	15.8	.5	812.5	8.1	16.2
14	C., M. & St. P. crossing, Reeseville	31.3	15.5	783.	29.5	1.9
15	Mouth of River	35.3	4.	.....	.....	.....

Authority: Levels run by Cooperation State and Federal Survey in 1906, except No. 14. The datum is that furnished by the C., M. & St. P. Ry.

Fox Lake Power.—Between Fox and Beaver Dam Lakes there is a fall of 22 feet, 12 feet of which is developed by a dam 175 feet long, located in the city of Fox Lake, and 1.5 miles from the lake. The water in the pond is practically the same elevation as Fox Lake.

The head varies from 13.2 feet in spring to 11.5 feet in the fall. One 26 inch and one 24 inch turbine are installed, rated at 100 h. p. under a 12 foot head and used to run a grist and flour mill. The actual power developed is stated by the owners to be 50 h. p.

On the right bank and below the dam is located a stone monument set some 40 years ago to limit the legal head. Its elevation is 795.1 feet. Between the foot of this dam and Beaver Dam Lake, there is a fall of 10 feet, but a good dam site is lacking because of low banks.

Beaver Dam Powers.

Three dams, with an aggregate head of 29 feet, are located in the city of Beaver Dam, furnishing power to one cotton and two woolen mills.

The Beaver Dam Cotton Mill dam is located at the immediate outlet of the lake near the junction of Mill and Madison Streets. Its length is 330 feet, including the dyke and spillway. The lawful head is 10½ feet, but it varies from 10.7 feet in spring to 8.7 feet in the fall. On September 25, 1906, the head was 9.4 feet. Beaver Dam Lake is an artificial lake of about eight square miles area made by the cotton mill dam. The dam was originally constructed of rubble masonry, the walls having a thickness of about four and one-half feet. In 1878 it was rebuilt of ashlar masonry in a very stable way. Previous to 1882, the water power was used to run a flour mill. The present cotton mill was constructed in 1883. The president of the Beaver Dam Cotton Mill is Mr. E. C. McFetridge.

The installation consists of three 44 inch Victor turbines. The company report an actual power of 150 h. p. Steam power is also used to the extent of 200 h. p. The company has kept a record of the height of water in the race since 1894.

Upper Woolen Mill.—One quarter of a mile below the cotton mill is located the upper woolen mill dam. This dam is 160 feet long and is built of 10x12 inch timbers. The head varies between 10 and 11.5 feet, but on September 25, 1906, was 11.1 feet.

Formerly three 45 inch turbines were installed, but since 1894, only one rated at full gate at 150 h. p. has been used. The owners state that this turbine actually delivers only 95 h. p. This woolen mill is run entirely by water power. The president of the company is Mr. M. A. Jacobs.

Previous to 1898, a grist mill was also run by water from this dam, using a 60 inch turbine under a 10 foot head. This mill is now using only steam power.

Lower Woolen Mill.—The third dam is located 2,300 feet below the one just described, owned by the Beaver Dam Woolen Mills Company, of which E. C. McFetridge is president and John T. Smith is treasurer. The woolen mill is located about 450 feet below the dam on a mill race about 1,000 feet long. This dam is about 400 feet long and 8 feet high.

The head varies between six and ten feet but is usually eight to nine and a half feet. At the time of the survey the head was 8.3 feet. One 60 inch turbine, rated at 103 h. p. is installed, but the actual developed power is given as 50 h. p. The company have also one 90 h. p. steam boiler. The mill runs ten hours per day.

Between the foot of the lower Woolen mill at Beaver Dam and the Leipsic dam, a distance of two and three-fourths miles, the river has a fall of 17.4 feet. Formerly the greater part of this fall was utilized by two dams, but at present the dams have been allowed to go to ruin.

Leipsic Dam.—This dam is owned by A. N. Grant. The head on the dam varies between 4.5 and 7.75 feet, but at the time of this survey it was six feet. One 40 and one 35-inch turbines are installed, rated at 83 h. p.; but reported to actually develop at usual gate opening only 40 h. p. This power is used to run a grist mill.

In the 16 miles of river between Leipsic and the Chicago, Milwaukee and St. Paul Railway crossing south of Reeseville, the river has a fall of 37.6 feet, the greater part of which is located between Leipsic and Lowell.

One abandoned dam site is located in the southeast quarter of Section nineteen, Township eleven North, Range fourteen East, at a point only 3,000 feet below the Leipsic dam. There is a fall of 8.1 feet in this distance. It seems probable that an additional dam could be constructed between Leipsic and Lowell.

Lowell Dam.—At this dam one turbine rated at 50 h. p., under a head of 11½ feet has been installed and is used to run the Enterprise Roller Mills. The owner, Mr. George O. Pease, reports that for every day in the year he has not less than three times as much water as he can use.

This is the last dam on this river.

Bark River.

Bark River rises in the southern part of Washington County in a small lake of same name. Its drainage area is 460 square miles. After a very circuitous course of 50 miles, it joins Rock River at Ft. Atkinson. Bark and Oconomowoc Rivers flow practically parallel to each other and only two to five miles apart for the upper half of their length. This river has a total fall of 190 feet or, 3.8 feet per mile, 100 feet of which is found in the 20 miles above Crooked Lake. Like the Oconomowoc, Bark River drains eight or more large lakes, four of which are simply expansions of the river. The following table gives a profile of the river, while the table on page 317 contains a statement of the powers located on the river.

Profile of Bark River.

No.	Station.	Distance.		Elevation above sea level.	Descent Between Points.	
		From mouth.	Between points.		Per mile.	Total.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Source in Bark Lake	0.0	.....	970. ‡	.....	.....
2	One mile above Merton	8.0	8.0	948.	22.0	2.7
3	Merton	9.0	1.0	940.	28.0	8.0
4	Hartland, above dam	13.0	4.0	.....	.....	.....
5	Hartland, below dam	13.2	0.2	900.	.....	.....
6	Lake Nagawicka	16.0	2.8	890.	10.0	3.5
7	Delafield, above dam	18.0	2.0	889.7	.3	1.5
8	Delafield, below dam	18.1	.....	882.7	7.	.....
9	Lower Dam; above	19.0	1.0	881. ‡	1.7	1.7
10	Lower Dam; below	19.0	.....	870.5‡	10.5	.....
11	Upper Nehmabin Lake	19.5	0.5	869.	1.5	3.
12	Crooked Lake	20.4	0.9	867.6	1.4	1.5
13	Utica	23.9	3.5	851.	16.6	4.9
14	Two miles west of Dousman. C. M. & St. P.	26.0	2.1	844.	7.0	3.4
15	Mouth of River	50.0	24.0	780.	64.	2.6

Authority: 1-3, United States Geological Survey, Topographic Map; 5 and 13. Railroad Elevations; Remainder, Wisconsin Geological Survey. Levels run by L. S. Smith in 1898.

Catfish River.

The Indian name for this river is Yahara. The river rises a few miles north of Madison on the divide between the Rock and Wisconsin Rivers. The river has a total drainage area of 530 square miles and a length of about 40 miles. In the upper half of its course, the river expands into four large lakes whose total area is about 60 square miles. These lakes have a decided steadying effect upon its flow, adding greatly to the value of the water power below. Between Lake Mendota, or Fourth Lake, and the mouth of the Catfish, the river has a fall of 78 feet, 71 feet of which is concentrated in the lower 20 miles of its length. In this distance, there are four dams with a total head of 48 feet.

A fairly complete profile of the river is shown in the following table:

Profile of Catfish River.

No.	Station.	Distance.		Elevation above sea level.	Descent between points.	
		From mouth.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Mouth of river	0.0	.....	772.	.....	.....
2	Fulton, below dam	1.5	1.5	772.5	22.	1.2
3	Fulton, above dam	.....	.....	788.9	16.4	.....
4	Stebbenville	6.5	5.	801.	12.1	2.4
5	Dunkirk:					
	Tail race	.....	.....	818.5	17.5	4.4
	Crest of dam	10.5	4.	830.6	12.1	.....
6	Stoughton, below dam	14.5	3.5	830.8	0.2	.....
7	Stoughton, above dam	.....	.....	840.4	9.6	.....
8	Lake Kegonsa, outlet	19.5	5.	843.	2.6	0.5
9	Lake Kegonsa, inlet	22.	2.5	843.	0.0	0.0
10	Lake Waubesa, outlet	25.1	3.1	844.	1.0	0.3
11	Lake Waubesa, inlet	27.1	2.	844.	0.0	0.0
12	Lake Monona, outlet	28.5	1.4	845.	1.0	0.7
13	Lake Monona, inlet	31.5	3.	845.	0.0	0.0
14	Lake Mendota, outlet	32.5	1.	849.	4.0	4.0
15	Lake Mendota, inlet	36.	3.5	849.	0.0	0.0

Authority: 1, United States Engineers. 2-7, surveyed by E. Hain, based on Chicago, Milwaukee and St. Paul Railway datum. 8-15, United States Geological Survey Topographic map.

Water Powers.

Fulton.—The first dam is located at Fulton, about one mile above the mouth of the river, and owned by the Janesville Electric Company. The company have installed three 39 inch turbines under a head of 16.5 feet and rated at 250 h. p., with a 150 K. W. three-phase generator. This power is used by the company to help out on the peak loads of the company's plant at Janesville and runs on an average 18 hours per day. A small generator is also installed in this power house for the purpose of assisting in the lighting of the city of Edgerton.

Stebbinsville.—The second dam was located at Stebbinsville, about six miles by river above Fulton. This property is owned by S. P. Stebbins and Mrs. Wm. I. Tilley. The dam formerly developed a head of about nine feet, but the center one-third was carried away by a freshet in 1904 and has not been rebuilt. The power was formerly used to run a flour and grist mill with three run of stone.

Dunkirk.—Four miles, by river, above Stebbinsville is located the next dam at the village of Dunkirk. Five turbines are here installed

under an average head of 11.6 feet, rated at 290 h. p. The wheels are of old style and probably do not develop more than 200 actual horse power. The owners of this power, Lynn Brothers, have leased same for ten years to the city of Stoughton for the purpose of lighting the city. A steam turbine of 150 h. p. is in use for this purpose also when the water power is not in use. The city of Stoughton has an option to purchase the power plant for $10,000 at the completion of its lease.

Stoughton.—The last dam is located in the city of Stoughton and is owned by C. L. Dearborn. Three turbines are installed under an average head of nine feet and used to run the Stoughton Flour mill. The mill runs 10 hours per day and has no steam power.

Madison.—One of the earliest powers to be developed in this region was the power at the outlet of Fourth Lake or Lake Mendota. For many years, a dam at this point developed a head of five feet and was used to operate a flour mil' In 1898 the city of Madison purchased the flooding privlege, intending to use the power for a sewerage pumping plant. This, however, has never been done. The city engineer uses the dam to regulate the stage of water in lakes Monona and Mendota, the water being drawn down in the fall and winter so as to store up the excess water of spring. A concrete lock has been installed at the dam site so as to allow the passage of boats between the adjacent lakes.

In addition to the above, small grist mills are located as follows:

Location.	Stream.	Owner.	Head.	Purpose.
			Head.	
Sec. 5 T. 8, R. 10 E.....	Token Creek.....	Chas. Elies.....	11	Grist mill.
	Token Creek.....	Wm. Zish	7	Grist mill.
Rockdale	Koshkonong Cr'k	Rockdale Roller Mill	9	Grist mill.
Waunakee.....	Spring Creek.....	W. H. Hodge	14	Grist mill.

CATFISH RIVER AT MADISON, WIS.

This station was established December 18, 1902, by L. R. Stockman. The gage is located on the lower side of the Main Street Bridge. An additional gage was maintained a few blocks away at the outlet of Lake Mendota, in order to keep a record of its water surface. Both gages are plain staffs, graduated to feet and tenths. That on the bridge was nailed to the middle pier. Both gages were read once daily by James Mackin. The channel is straight both

above and below the station for over 1,000 feet; it has a width of 55 feet and does not overflow. The flow is sluggish and is affected by back water from Lake Monona.

Bench mark No. 1, elevation assumed 1,000 feet, is the water table at the northwest corner of Williamson and Water Streets. Bench mark No. 2, elevation 1,004.46 feet, water table at the west corner of Hausmann's malt house. The 17-foot mark on gage at Main Street Bridge has an elevation of 992.15 feet. The 16-foot mark on gage in Lake Mendota has an elevation of 997.27 feet, or 7.19 feet below bench mark No. 2. The 16-foot mark at the dam is 6.12 feet above the 16-foot mark of Main street gage.

This station was discontinued August 4, 1903.

Discharge measurements of Catfish River at Madison, Wis., in 1903.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	Second-feet.
January 8	L. L. Stockman	14.20	a53
January 27	do	14.10	60
February 23	do	13.95	58
March 30	do	15.00	197
April 18	do	14.85	174
July 21	E. E. Murphy	15.05	35

a Partly frozen.

Mean daily gage height, in feet, of Catfish River at Madison, Wis., for 1902.

Day.	Dec.	Day.	Dec.	Day.	Dec.
18	13.9	23	14.00	28	14.30
19	13.9	23	14.10	29	14.30
20	13.9	25	14.10	30	14.30
21	13.9	26	14.30	31	14.30
22	13.9	26	14.60		

Mean daily gage height, in feet, of Catfish River at Madison, Wis., for 1903.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	14.10	14.00	14.00	15.00	14.80	17	14.80	14.10	15.10	14.90	.....
2	14.10	14.00	14.10	15.00	14.55	18	14.30	14.10	15.20	14.80	.....
3	14.10	14.10	14.10	15.00	14.50	19	14.30	14.10	15.30	14.80	.....
4	14.10	14.30	14.30	15.00	14.50	20	14.30	14.00	15.30	14.80	.....
5	14.10	14.20	14.30	15.00	14.50	21	14.30	14.00	15.20	14.80	.....
6	14.00	14.20	14.30	15.00	14.60	22	14.30	14.00	15.20	14.80	.....
7	14.00	14.20	14.30	14.90	14.60	23	14.30	14.00	15.20	14.80	.....
8	14.00	14.10	14.30	14.90	14.65	24	14.30	14.00	15.20	14.80	.....
9	14.10	14.10	14.60	14.80	14.70	25	14.30	14.00	15.20	14.80	.....
10	14.10	14.10	14.60	14.80	.....	26	14.20	14.00	15.20	14.80	.....
11	14.20	14.10	14.70	14.80	.....	27	14.20	14.00	15.10	14.80	.....
12	14.20	14.10	14.80	14.90	.....	28	14.20	14.00	15.10	14.70	.....
13	14.20	14.00	14.70	14.90	.....	29	14.10	.....	15.10	14.65	.....
14	14.30	14.00	14.80	14.90	.....	30	14.10	.....	15.10	14.65	.....
15	14.30	14.00	14.70	14.90	.....	31	14.10	.....	15.00	.....	.....
16	14.30	14.10	14.70	14.90	.....						

Water powers on the smaller tributaries of Rock River.

No.	Location.	Stream.	Head.	H. P. installed.	Use.
1	Brodhead	Sugar River	11	120	Flour, light, plow factory
2	Attica	" "	7	50	Grist and woolen mills.
3	Dayton	" "	12	100	Mill not in use.
4	Belleville	" "	9	100	Electric light and flour.
5	Monticello	Little Sugar River	8	50	Grist mill.
6	New Glarus	" " "	...	Abandoned	Grist mill not used.
7	Mount Vernon	" " "	9	36	Grist mill and feed.
8	Albany	" " "	7	160	Grist mill and woolen mill.
9	Gratiot	Wolf River	8	40	Grist mill.
		Pecatonica, w. br'nch	8	100	Feed mill.
10	Darlington	" "	4	50	Feed mill.
11	Darlington	" "	8	190	Electric light and button factory.
12	Calamine	" "	15	14	
13	Martin	" "	...	...	
14	Token Creek, S. 5, T. 8, R. 10 E	Token Creek	11	25 ±	Flour mill.
15	Rockdale	Koshkonong Creek	8.5	75	Flour and feed.
16	Cambridge	" "	12	50	Grist and feed.
17	Evansville	Allen's Creek	...	Dam removed	Power not used.
18	Shopiere	Turtle "	5	33	Flour mill.
19	Delavan	" "	...	...	" "
20	Whitewater	Whitewater Creek	12	100	" "
21	Whitewater, above	" "	9	75	Power abondoned.
22	Sec. 20, T. 2 N., R. 16 E	Outlet Delavan Lake	...	...	
23	Afton	Bass Creek	...	...	Flour mill.
24	Avon	Sugar "	...	...	
25	Fremont	Rubicon River	...	...	
26	Neosho	" "	10	40	Grist mill.
27	Saylesville	Rubicon	12	...	" "
28	Marshall	Waterloo Creek	10	21	" "
29	Hartford	Rubicon River	18	80	Flour mill.
30	Dousman	Scuppernong Creek	9½	78	Feed mill.
31	Stone Bank	Oconomowoc River	13	20	" "
32	Dill	Pecatonica River	...	...	
33	Albany	Sugar River	8	60	Linen mill.
34	Blanchardville	Dodger Creek	7½	42	Planing mill.
35	Argyle	Pecatonica River	10½	30	Feed mill.
36	Palmyra	Scuppernong River	15	50	Rye flour and feed.
37	Merton	Bark River	10	50	Flour and feed.
38	Hartland	" "	...	...	Not used.
39	Delafield	" "	7	30	Flour mill.
40	One mile West of Delafield	" "	19½	70	" "
41	Rome	" "	8	50	Saw mill.
42	Rome	" "		120	Roller mills.
43	Waterloo	Waterloo Creek	10	75	Flour and feed.
44	Mayville	E. Branch Rock River	12	125	N. W. Ironworks.
45	Mayville	" "	11	...	"
46	Kekoskee	E. Branch Rock River	10	...	Grist mill.
47	Waupun	" "	6½	57	Flour mill.
48	Darnville	Crawfish River	9	50	Rye flour and feed.
49	Columbus	" "	9½	70	Flour and feed.
50	Hebron	Bark River	...	...	Feed mill; saw mill.
51	Sullivan	" "	...	...	Feed mill; flour mill.
52	Lake Mills	Rock Creek	9	43	Flour mill.
53	2 mi. W. of Milford	" "	...	...	" "
54	Johnson Creek	Spring Brook	...	...	Creamery.
55	Alderly	Ashippan Creek	14	55	Grist mill.
56	North Lake	Oconomowoc River	10	31	" "
57	Outlet L. Okouchee	" "	10.7	...	" "
58	Oconomowoc	" "	8	...	Flour mill.
59	Fall River	Crawfish River	13	100	Grist mill.
60	Elba	" "	11	60	" "
61	Waterloo	Waterloo Creek	10	...	Electric light and feed.
62	Marshall	" "	12	...	Grist.

FOX RIVER.

Drainage and Fall.—Fox river, a tributary of Illinois river rises in the northern part of Waukesha County and flows southward through Racine and Kenosha Counties. The total drainage area in Wisconsin, (1,000 square miles) has a length north and south of 50 miles and a width of 35 miles. The entire drainage is in the Niagara limestone region, and like the watershed of Rock river the limestone is deeply covered by glacial deposits. The largest concentration of fall is found at Waukesha, but below Waukesha the river has an average fall of only 1.4 feet per mile, or a trifle more than the average of Rock river. In this stretch of 51 miles, the river winds in a flat marshy bottom, with few opportunities for dams. In spite of the fact that many of its tributaries rise in large lakes, the flow of the river is reported to be very irregular, the low water flow in July, August and September being inadequate to run the turbines.

No regular gaging stations have been maintained. The pot hole topography which is so characteristic of this region is very unfavorable for large run-off.

The fall in the river so far as known is shown in the table.

Profile of Fox River.

No.	Station.	Distance.		Elevation above the sea.	Descent between points.	
		From State Line.	Between points.		Total.	Per mile.
		Miles.	Miles.	Feet.	Feet.	Feet.
1	Illinois line	0.0	0.0	.....	.....	.....
2	Fox river station	4.5	4.5	741	.....	.....
3	Burlington	15.0	10.5	748	7	0.5
4	Rochester, below dam	20.0	5.0	.....	.....	.....
5	Rochester, above dam	20.0	0.0	.....	5	.....
6	Waterford, below dam	21.5	1.5	.....	.....	.....
7	Waterford, above dam	21.5	0.0	.....	6	.....
8	Wis. Cen. Ry., N. of Mukwonago	38.5	17.0	776	.....	.....
9	Waukesha, C.& N.W.Ry. crossing	51	12.5	794	18	1.4
10	3 miles above Waukesha	55	4.0	814	20	5.0
11	Pewaukee Lake	62	7.0	848	34	4.9

Authority: 2, 9, C. & N. W. Ry.; 3, 8, 10, Wis. Central Ry.; 11, L. S. Smith.

Water Powers.

Flour and feed mills are located on Fox River at Wilmot, Rochester, Waterford, and Waukesha, but only the latter mill has any railroad facilities. In all of the mills expensive roller machinery was early installed for the purpose of manufacturing flour, but for reasons explained elsewhere, this machinery is but little used at present.

Wilmot Power.—A six-foot turbine is here installed under a head of four feet. This power was formerly used to run a roller mill with a capacity of 100 barrels per day, but is now used to run a feed and saw mill. The power is owned by Walter Carey. Silver Lake, the nearest railroad station is located three miles distant.

Rochester Power.—The Rochester dam is located about 20 miles above Wilmot. Three turbines, 36, 54 and 56 inch respectively, are here installed under an average head of four feet. This mill was re-fitted in 1885 with a complete roller outfit, but because of the scarcity and poor quality of local wheat supply has been used but little for many years. The mill is used for grinding feed and buckwheat flour. This dam backs the water nearly to the next power above at Waterford. Honey Creek 4.5 miles distant is the nearest railroad station.

Waterford Power.—This mill is built of stone and is in a good state of repair. Four turbines, including one 45 inch, two 40 inch and one 35 inch, are installed under an average head of 5.5 feet, and rated at about 100 horse power.

This dam has a much larger pondage than any other dam on the river, backing the water up the river for many miles. The mill is fitted for manufacturing roller flour, but power is also used for furnishing electric light for the city of Waterford. Honey Creek, the nearest railroad station is seven miles distant.

Waukesha Powers.—This mill is located near the center of Waukesha and near the depot of the C. M. & St. P. Railroad. A six foot stone dam about two blocks above the mill is located near the head of the rapids. From the dam, the water is conducted by a long mill race to the mill, where a head of about 13 feet is usually developed, except in summer when the head reduces to nine. The present head could be considerably increased by excavating an adequate tail race for a short distance. One Victor 50 inch turbine is installed and used to run a flour and feed mill 10 hours per day. A 50 horsepower gasoline engine is also installed.

About two miles above Waukesha is another water power owned by Chas. Deisner. Three small turbines are installed under a 20 foot head and used to run a feed and saw mill.

Other powers on tributaries of Fox river.

Name of stream.	Location of power.	Head developed.	Purpose for which power is used.
		Feet.	
Pewaukee river	Pewaukee	8.	Feed mill and electric light.
Mukwonago river	Eagleville	13.5	Feed mill.
do	Mukwonago	6.	Roller mill, 3-45 inch turbines.
Honey Creek	East Troy	13.	Feed and flour mill, 1-25 inch turbine
do	Hilburn	8.	Feed mill.
do	Lauderdale	8.	Flour and feed.
Sugar Creek	Vienna	12.	Flour and feed, 2-34 inch turbines.
White River	Geneva	14.	Flour and feed, 2-26 inch turbines.
do	Geneva	9.	Electric light, 2-56 inch turbines.
do	Burlington	8.	1-45 inch and 1-50 inch turbine used for electric light and power. Owner, Burlington Light & Power Co.
do	Lyons	.....	

MISSISSIPPI DRAINAGE.

The water powers of Chippewa, Black and Wisconsin rivers have been elsewhere discussed. There remains of this drainage a large number of smaller rivers some of them, notably Trempealeau and La Crosse, of considerable importance as power producers.

As a rule the rivers of this class have a very rapid fall in their upper reaches where they flow in rock. Many of these rapids were formerly developed and used for saw mills. The deforestation of this area united with the high gradient of the drainage areas has resulted in constantly increasing freshets and correspondingly long periods of extreme low water flow.

As the rivers approach the Mississippi these rivers show a decreasing gradient, usually flowing in a sandy valley where dams are difficult to maintain.

The size of the streams can be seen from the following table of drainage areas:

	River.	Drainage area
1	Platt	320 square miles.
2	Grant	300 " "
3	Bad Ax	150 " "
4	La Crosse	485 " "
5	Coon	150 " "
6	Trempealeau	685 " "
7	Beef	430 " "
8	Rush	180 " "

Water powers of La Crosse River.

Location.	River.	Turbine.		Remarks.
		Head feet.	Horse power	
La Coosse	La Crosse	15	40	
West Salem	do	8	8	Flour and Feed.
Sparta	do	10	18	Grist.
do	do	6	61	Flour and Feed.
Angelo	do	10	75	Electric Light.
Leon	Little La Crosse	9	48	Grist.
Sparta	do do	18	70	Grist mill.
Holman	Half Way Creek	16	40	Flour and Feed.
Burns	Burns Creek	10	10	Grist mill.
Sparta	Beaver Creek	14	28	Planing and Sawing.
Bane Mills	Bastwick Creek	9	10	Used only in winter.
Sec. 14 T. 17 R., 5 W	Big Creek	15	25	Flour and Feed.
	Total	140	473	

Water powers of Trempealeau River.

Location.	River.	Turbine.		Remarks.
		Head feet.	Horse power.	
Arcadia (six miles below)	Trempealeau	10		Undeve'oped.
Whitehall	do	9	140	Flour mill.
Blair	do	9	120	do do
Taylor	do	6½	30	do do
Hixton	do	16	75	do do
Sechlerville	do	6		
Pigeon Falls	Pigeon Creek.	11	60	Grist mill.
Sec. 10, T. 22 N., R. 7 W.	do do	9	56	do..do
Sec. 5, T. 18 N., R. 9 W.	Big Tamerack Creek	16	60	do..do
Independencs	Elk Creek	12	69	do..do
Sec. 22 T. 24 N., R. 9 W.	do do	12	30	
Sec. 31 T. 23 N., R. 8 W.	do do	9	45	Grist mill.
Sec 17 T. 23 N., R 10 W.	do do W. Branch	10	26	do..do
	Total	135½	711	

Water powers on smaller rivers.

Location.	River.	Turbine.		Remarks.
		Head.	Horse Power.	
		Feet.		
El Paso, south ½ mile	Rush River	10	50	Grist mill.
El Paso	do do	8		Not used now.
Martell	do do	4½	4	Wool carding.
Sec. 32, T. 27 N, R. 16 W	do do	9	30	Saw mill.
Osseo	Beef River	10	100	Grist mill.
Mondovi	do do	20	100	do
Osseo, 10-24-7	do do	10	17	do
Mondovi	Mill Creek	10	25	do
Chaseburg	Coon River	8	25	do
Coon Valley	do do	13	100	do
Sec. 24, T. 12, R. 6 W	Bad Ax	9	30	do
Newton, Sec. 23, T. 13, R 6 W	do	11	10	do
Trim Belle	Trim Belle Cr	11	45	do
" "	do do	10	43	do
Shelby	Norman Cr	16	30	do
Prairie du Chien	Artesian Wells		10	do
Sec. 6, T. 99 N, R. 11 W	Waumandee Cr.	7		Mill burned.
Sec. 36, T. 26, R. 14 W.	Eau Galle Cr	23	50	Light and power, Grist mill.
Sec. 6, T. 23, R. 13 W	Big Bear Cr	8	65	Flour mill.

APPENDIX.

BEING A SYNOPSIS OF DAM CHARTERS GRANTED BY THE TERRITORIAL AND STATE LEGISLATURES FROM 1838 TO 1907.

DAM CHARTERS.

Grants of dam privileges by the legislature of Wisconsin, 1838–1907.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1838	40	Manitowoc river.....	Manitowoc...	William B. Slaughter, Sec. 19, T. 19 N., R. 23 E.
1839	45	Rock river.	Jefferson.....	Charles F. Hoodhue et al., Sec. 4, T. 8 N., R. 15 E.
1839	49	Rock river.....	Dodge.....	Moses M. Strong et al., Secs. 6, 7, T. 11 N., R. 16 E.
1840	7	Manitowoc river.....	Manitowoc...	Wm. H. Bruce et al., Secs. 23, 25, 26, T. 19 N., R. 23 E.
1842	p. 8	Pewaukee lake.....	Waukesha ...	Asa Clark, Sec. 9, T. 7 N., R. 19 E.
1842	p. 9	Rock river.....	Jefferson.....	D. G. Kendall et al., Secs. 2, 11, T. 6 N., R. 14 E.
1842	p. 11	Manitowoc river.....	Manitowoc...	Oliver C. Hubbard, Sec. 23, T. 19 N., R. 23 E.
1842	p. 44	Crawfish river.....	Jefferson.....	Lucius I. Barber et al., Sec. 11, T. 6 N., R. 14 E.
1842	p. 84	Oconto river.....	Oconto.....	Geo. Lurwick, Sec. 24, T. 28 N., R. 21 E.
*1843	p. 21	Milwaukee river.....	Ozaukee.....	Henry Thien, Sec. 23, T. 9 N., R. 21 E.
†1843	p. 22	Fox river.....	Racine	Levi Godfrey et al., Secs. 11, 2, T. 3 N., R. 19 E.
1843	p. 32	Fox river.....	Racine	David L. Wells et al., Sec. 32, T. 3 N., R. 19 E.
‡1843	p. 34	Rock river.....	Rock.....	Clonden Stoughton et al., Sec. 21, T. 4 N., R. 12 E.
a 1843	p. 25	Rock river.....	Rock.....	Wm. H. H. Bailey et al., Sec. 36, T. 3 N., R. 12 E.
1834	p. 36	Peshtigo river.....	Marinette....	David Jones et al., Sec. 19, T. 30 N., R. 23 E.
1844	p. 37	Rock river.....	Jefferson.....	C. M. Bonton et al., Sec. 3, T. 8 N., R. 15 E.
1844	p. 37	Milwaukee river	Milwaukee...	Jas. H. Rogers, Sec. 4, T. 7 N., R. 22 E.
1844	p. 38	Oconto river.....	Oconto.....	Jno. P. Arndt, Sec. 30, T. 28 N., R. 21 E.
1844	p. 71	Sugar river.....	Green	Jas. Campbell et al., Sec. 28, T. 3 N., R. 9 E.
1845	p. 99	Rock river.....	Dodge.....	Jno. Hustis, Sec. 9, T. 10 N., R. 16 E.
1845	p. 104	Milwaukee river.....	Milwaukee...	Joachim Gruenhagen, Sec. 20, T. 8 N., R. 22 E.
b 1846	p. 93	Milwaukee river.....	Ozaukee.....	Owners of land, Secs. 25, 36, T. 11 N., R. 21 E.
1846	p. 113	Wisconsin river.....	Portage.....	Abraham Brawley, Secs. 31-2, T. 24 N., R. 8 E.
1847	p. 16	Rock river.....	Jefferson.....	Lyman E. Boomer et al., Secs. 8, 9, T. 8 N., R. 15 E.
c 1847	p. 44	Wisconsin river.....	Wood	Henry Clinton et al., Sec. 6, T. 22 N., R. 6 E.
1847	p. 46	Sugar river.....	Green	Wm. Jones, Sec. 15, T. 2 N., R. 9 E.
1847	p. 103	Milwaukee river.....	Ozaukee.....	Michael Bratt, Sec. 34, T. 12 N., R. 21 E.
1847	p. 103	Milwaukee river.....	Ozaukee.....	Phineas M. Johnson, Sec. 24, T. 10 N., R. 21 E.
1847	p. 103	Milwaukee river.....	Ozaukee.....	Owners of land, Sec. 24, T. 10 N., R. 21 E.
1847	p. 103	Milwaukee river. ..	Ozaukee.....	B. H. Mooers et al., Sec. 25, T. 10 N., R. 21 E.
1847	p. 104	Fox river.....	Winnebago...	Harvey Jones et al., Secs. 22, 27, T. 20 N., R. 17 E.
1847	p. 121	Wolf river.....	Shawano.....	Samuel H. Farnsworth, Sec. 25, T. 27 N., R. 15 E.
1847	p. 179	Sheboygan river.....	Sheboygan...	Samuel B. Ormsby, Sec. 28, T. 15 N., R. 23 E.
1848 T	p. 9	Milwaukee river.....	Milwaukee...	F. Wm. Allerding, Sec. 4, T. 7 N., R. 22 E.
d 1847 T	p. 13	Rock river.....	Rock	A. Hyatt Smith et al., Secs. 1, 2, T. 2 N., R. 12 E.
1848	p. 38	Oconto river.....	Oconto.....	Elisha Morrow, Secs. 26, 35, T. 28 N., R. 20 E.

* Amended, Chap. 150, Laws 1854, repealing requirements for lots, log slides, etc.

† Amendment, Laws 1845, p. 95, restricting the height of water to prevent damage, etc.

‡ Amendment, Chap. 333, Laws of 1851, restricting the height of dam and prohibiting injury.

a Laws of 1846, p. 116, amendment of provisions regarding height, manner of construction, etc., and amended again in the same respect by Chap. 354, Laws of 1855.

b Amendment, Chap. 159, Laws of 1855, changing land description to read N. E. ¼ Sec. 26, N. W. ¼ of Sec. 25, T. 11 N., R. 22 E.

c Amendment, Chap. 88, Laws of 1851, transferring the grant conditionally and changing provisions.

d Amendment, Chap. 214, Laws of 1850, provisions regarding damages to land from back flow.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1848 T	p. 43	Milwaukee river.....	Ozaukee.....	Joseph Carley et al., Sec. 6, T. 11 N., R. 21 E.
1848 T	p. 68	Peckatonica river...	Green.	Cadwallader C. Washburne et al., Secs. 20-1, T. 1 N., R. 6 E.
1848 T	p. 83	Fox river.....	Marquette. ..	Wm. A. Barstow, Sec. 17, T. 15 N., R. 10 E.
1848 T	p. 106	Peckatonica river...	Green.....	Edward S. Hanchett et al., Secs. 31-2, T. 1 N., R. 6 E.
1848 T	p. 126	Milwaukee river.. ..	Washington..	Barton Salisbury, Sec. 12, T. 11 N., R. 20 E.
1848 T	p. 129	Fox river.....	Winnebago. .	Curtis Reed, Sec. 22, T. 20 N., R. 17 E.
1848 T	p. 139	Milwaukee river. ..	Milwaukee...	Cicero Comstock et al , Secs. 4, 5, T. 7 N., R. 22 E.
1848 T	p. 142	Fox river.....	Columbia	J. Sprague Pardee, Sec. 3, T. 12 N., R. 10 E.
1848 S	p. 132	Peckatonica river...	La Fayette...	Samuel Young, Sec. 1, T. 1 N., R. 5 E.
1848 S	p. 145	Crawfish river.....	Jefferson.	Norman Pratt, Sec. 4, T. 7 N., R. 14 E.
1849	40	Milwaukee river.. ..	Ozaukee.....	Oscar Day, Sec. 10, T. 11 N., R. 21 E.
1849	78	Rock river.....	Jefferson.	Cyrus Curtsi, Sec. 4, T. 5 N., R. 14 E.
1849	200	Peckatonica river...	La Fayette...	Jno. M. Keep, Sec. 3, T. 2 N., R. 3 E.
a 1850	94	Rock river.....	Rock.....	Ira Miltamore, Sec. 21 etc., T. 2 N., R. 12 E.
1850	118	Manitowoc river.....	Manitowoc...	Pliny Pierce, Sec. 14, T. 19 N., R. 23 E.
1850	120	Fox river....	Racine.....	Jas. Catlin, Sec. 33. T. 3 N., R. 19 E.
1850	189	Grand river.....	Green Lake..	Thos. C. Snow et al., Sec. 13, T. 14 N., R. 11 E.; Sec. 7, T. 14 N., R. 12 E.
1851	36	Peckatonica river..	La Fayette...	Richard H. McGoon, Sec. 20, T. 3 N., R. 3 E.
1851	80	Milwaukee river.....	Ozaukee.....	Geo. W. Foster, Sec. 29, T. 12 N., R. 21 E.
1851	126	Sugar river.....	Rock.....	Alvin D. Carpenter, Sec. 20, T. 1 N., R. 10 E.
1851	129	Oconto river.....	Oconto..	Merrick Murphy, Sec. 34, T. 28 N., R. 20 E.
1851	173	Little Wolf river near Grignoa Mill.	.....	Napoleon B. Millard.
1851	203	White river.....	Marquette. ..	Ebenezar Dakin, Sec. 17, T. 17 N., R. 11 E.
1851	206	Long Pond.....	Fond du Lac.	Harrison C. Hobart et al., Secs. 25, 26, T. 14 N., R. 19 E.
1851	208	Manitowoc river.....	Manitowoc...	Chas. Klingholz, Sec. 26, T. 19 N., R. 23 E.
b 1851	248	Milwaukee river.....	Milwaukee...	Henry Thien, Sec. 20, T. 8 N., R. 22 E.
c 1851	259	Peckatonica river...	La Fayette...	Samuel George, Sec. 1, T. 2 N., R. 3 E.
1851	333	Baraboo river.....	Sauk.....	Ann Garrison, Sec. 27, T. 12 N., R. 7 E.
1852	59	Manitowoc river.....	Manitowoc..	Chas. Klingholz et al., Sec. 16, T. 19 N. R. 23 E.
1852	76	Fox river.....	Kenosha.....	Joas. Davenport, Sec. 30, T. 1 N., R. 20 E.
1852	116	Manitowoc river.....	Manitowoc...	Edward D. Beardsley et al., Sec. 10, T. 19 N., R. 23 E.
1852	275	Menomonee Shioc river 1 mile from mouth.	.....	Frederick F. Davis.
1852	403	Grand river.....	Green Lake..	John M. Seward, Sec. 14, T. 14 N., R. 12 E.
1852	501	Grand river.....	Green Lake .	John B. Seward, Sec. 7, T. 14 N., R. 13 E.
1853	23	Milwaukee river. ...	Milwaukee...	Peter Bender et al., Sec. 30, T. 8 N., R. 22 E
1853	141	Wisconsin river	Portage	Wm. Dunton, Sec. 8, T. 23 N., R. 8 E.
1853	152	Wisconsin river	Wood	Luther Hanchett, Sec. 36, T. 22 N., R. 5 E.
1853	177	La Crosse river.....	La Crosse....	Monroe Palmer, Secs. 34, 27, T. 17 N., R. 6 W.
1853	208	Black river	Jackson	Jacob Spaulding, Sec. 15, T. 21 N., R. 4 W.
1853	212	Peckatonica river...	La Fayette ..	Richard McGoon, Sec. 20, T. 3 N., R. 3 E.
1853	221	Baraboo river, town of Caledonia	.....	Nathan H. Wood.
1853	226	Fox river	Kenosha	Asahel W. Benham, Sec. 30, T. 1 N., R. 20 E.
1853	247	Wisconsin river	Wood	Geo. Neaves et al., Sec. 18, T. 22 N., R. 6 E.
1853	258	Wolf river, La Motte.	Shawano	Geo. F. Wright et al.
d 1853	270	Wisconsin river	Sauk.	John Marshall et al., Sec. 15, T. 13 N., R. 6 E
1853	342	Honey creek	Milwaukee...	Earnest Prieger, Sec. 28, T. 7 N., R. 21 E.
e 1853	376	Peckatonica river...	La Fayette ..	John W. Stewart, Secs. 3, 4, 9 or 10, T. 1 N., R. 5 E.
1853	408	North Duck creek...	Columbia ...	Evan Edwards, Sec. 6 T. 12 N., R. 12 E.
1854	9	Milwaukee river	Ozaukee	Chas. Quenten et al., Sec. 31, T. 10 N, R 22 E.

a Amendment, Chap. 87, Laws of 1854, providing for the recovery of damages on account of injury to property caused by back flow.
b Amendment, Chap. 151, Laws of 1854, repealing requirement for locks, etc.
c Repealed, Chap 159, Laws of 1857.
d Repealed by Chap. 69, Laws of 1860.
e Amended, Chap. 186, Laws of 1873, land description changed to read Secs. 3, 4 or 9, T. 1 N. R. 5 E.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1854	82	Wisconsin river	Marathon	Chas. Shuter et al., T. 29 N., R. 7 E.
1854	98	Sheboygan river.....	Sheboygan ...	Jonathan Lighton, Sec. 31, T. 15 N., R. 23 E.
1854	111	Sugar river	Green	Jos. Goss, Sec. 23, T. 2 N., R. 9 E.
1854	140	Grand river.....	Green Lake..	Austin McCracken, Sec 8, T. 14 N., R 13 E.
1854	231	La Crosse river.....	La Crosse....	Monroe Palmer, Secs. 34, 27, T. 17 N., R. 6 W.
1854	250	Baraboo river	Sauk	John J. Jarvis, Sec. 29, T. 12 N., R. 5 E.
1854	275	Manitowoc river	Manitowoc ..	Chas. Klingholz, Sec. 26, T. 19 N., R. 23 E.
1854	329	Grand river...	Green Lake..	Jas. F. Defrees, T. 14 N., R. 11 E.
1855	88	Milwaukee river.....	Ozaukee	Geo. W. Foster, Sec. 28, T. 12 N., R 21 E.
1855	149	Sheboygan river.....	Manitowoc ..	Henry F. Belitz et al., Sec. 30, T. 17 N., R. 21 E.
1855	186	Manitowoc river	Manitowoc ..	Thos. W. Baker et al., Sec. 10, T. 19 N., R. 23 E.
1855	188	Peckatonica river...	La Fayette ..	Ezra Wescott, Sec. 1 or 2, T. 1 N., R. 4 E.
1855	214	Sugar river.....	Green	Jacob Teneyck, Secs. 2 and 3, T. 1 N., R. 9 E.
1855	251	Red Cedar river.....	Dunn.....	John H. Knapp et al., Sec. 24, T. 26 N., R. 13 W.
1855	288	Mullet river, at outlet of Mullet Lake.	... .	C. D. Gordon.
1855	313	Bass creek.....	Rock	Jno. L B. Thomas, Sec. 14, T. 2 N., R. 11 E.
1855	327	St. Lawrence creek.	Waupaca	Caleb S. Ogden, Sec. 22, T. 23 N., R. 12 E.
1855	361	Baraboo river.....	Juneau.....	Joel Bishop, Sec. 35, T. 14 N., R. 2 E.
a 1856	58	Baraboo river.	Sauk	Jos. McKay, Sec. 10, T. 12 N., R. 4 E.
1856	176	Lemonweir river....	Juneau.....	Milton M. Maughs, Sec. 10, T. 15 N., R. 4 E.
1856	80	Clearwater river	Eau Claire...	Wm. Carson et al., Sec. 14, T. 27 N., R. 9 W.
1856	305	Little river.....	Oconto.....	Geo. Smith, Sec. 24, T. 28 N., R. 20 E.
1856	3 8	Badfish creek.....	Rock	Noah Davenport, Sec. 1, T. 4 N., R. 10 E.
1856	397	Flemings creek.....	La Crosse....	Lloyd L. Lewis, Sec. 24, T. 18 N., R 7 W.
1856	481	Apple river	Polk	Apple River Dam Co., Sec. 33, T. 33 N., R. 16 W
1856	534	Ravine river	Columbia	Peter Hanston, Sec 34, T. 12, 13 N., R. 11 E.
1857	99	Waupaca river.....	Waupaca ...	Chas. L. Gormar et al., Sec. 36, T. 22 N., R. 12 E
1857	164	Oconto river....	Oconto.....	Rufus Andrews, Secs. 23, 26, T. 28, N., R. 19 E.
1857	183	Fox river	Racine	Jas Scott et al., Sec. 14, T. 3 N., R. 19 E.
b 1857	195	Oconto river	Oconto.....	Henry Volk, Sec. 25, T. 28 N., R. 19 E.
1857	237	Lemonweir river	Juneau	Amasa Wilson, Secs. 7 & 8, T. 16 N., R. 3 E.
1857	318	Stream in Scott town	Sheboygan ..	E. W. Chapin.
1857	335	Lemonweir river...	Juneau	Newell Dustin, Sec. 16, T. 15 N., R. 4 E.
1857	360	Little Wolf river	Waupaca	B. F. Phillips, Sec. 8, T. 22 N., R. 14 E.
1857	368	Flambeau river.....	Gates	Wm. H. Gleason, Sec. —, T. 35 N., R. 5 W.
1858	254	Menomonee river....	Marinette....	Anson Bangs, Sec. 13, T. 31 N., R. 22 E.
1858	278	Patrick creek	Dodge.....	James Hart, Secs. 26 & 35, T. 13 N., R. 16 E.
1859	111	Wisconsin river.....	Portage	Isaac Ferris, Sec. 17, T. 23 N., R. 8 E.
1860	74	Peckatonica river...	La Fayette ..	Wm. Knowles, Sec. 11, T. 1 N., R. 5 E.
1861	36	Red Cedar river.	Dunn	Jno. H. Knapp et al., Sec 26, T. 28 N., R. 13 W
1861	42	Red Cedar river	Dunn	Burrage B. Downs, Sec. 34, T. 27 N., R. 13 W.
1861	52	Black river	Jackson.....	Andrew Sheppard, et al., Sec. 33, T. 21 N., R 4 W
1861	59	Scarboron river.....	Kewaunee ...	J. R. Slaussen et al., Sec. 35, T. 24 N., R. 23 E
1861	69	Milwaukee river.....	Ozaukee	Henry W. Stillman, Sec. 3, T. 11 N., R. 21 E.
1863	153	Milwaukee river.....	....	John Ehlers.
1863	327	Honey creek.....	Sauk	Alexander M. Morrill et al., Sec. 17, T. 9 N., R. 6 E.
1863	349	Kickapoo river.....	Richland	Isaac R. Lawton et al., Sec. 6, T. 12 N., R. 2 W
1864	300	Chippewa river	Chippewa....	Adin Randall, Sec. 30, T. 30 N., R. 7 W.
c 1864	302	Willow river.....	Polk.	Willow River Dam Co., T. 32 N., R. 15 W.
1864	325	Red Cedar river	Barron	John H. Knapp et al., Sec. 21, T. 35 N., R. 11 W.
1864	389	Peckatonica river...	La Fayette..	Satterlee Warden, Sec. 4, T. 1 N., R. 4 E.
1865	319	Chetack river.....	Barron.....	Andrew Tainter et al., Sec. 20, T. 33 N., R. 10 W.
1866	122	Willow river at Hudson.	St. Croix	Daniel A. Bladwin.
1866	99	Red Cedar river.....	Dunn	John H Knapp, Sec. 20, T. 29 N., R. 12 W.
1867	328	Chippewa river.....	Chippewa....	Eagle Rapids Dam Co., Sec. 22, T. 29 N., Range 8 W.

a Chap. 167, Laws of 1857, amended in relation to the height of dam, etc.
b Chap. 134, Laws of 1859, amended, providing for the maintenance of a boom.
c Amended, Chap. 366, Laws 1868, providing for height of dam, rates of toll, management, etc.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
a 1867	503	Little Wolf river....	Waupaca	Wisconsin Mf'g. et al., Sec. 8, T. 22 N., R. 14 E.
1867	563	West Twin river.....	Manitowoc ..	Henry Nachtway, Sec. 7, T. 21 N., R. 23 E.
1867	568	Chippewa river.....	Chippewa...	Jno. O. French et al., Secs. 19, 20, 29, 30, T. 30 N., R. 7 W.
1867	586	Little Wolf river.....	Waupaca	Jas. Meikeljohn, Sec. 34, T. 23 N., R. 13 E.
1867	587	Little Wolf river....	Waupaca	J. P. More et al., Sec. 1, T. 22 N., R. 13 E.
1868	216	Big Rib river.....	Marathon....	Jno. Basemann, Sec. 28, T. 29 N., R. 5 E.
1868	265	Little Wolf river....	Waupaca	Jas. R. Buckstaff et al., Sec. 11, T. 23 N., R. 13 E.
b 1868	376	Apple river.....	Polk	Jno. A. Gore, Sec. 12, T. 32 N., R. 17 W.
1868	461	Vermillion river	Barron	Jas. Bracklin et al., Sec. 26, T. 34 N., R. 12 W.
1868	489	Lyndon creek, near Lyndon village.	Juneau	Jno. Fitzgerald et al.
1869	223	Two streams near Lake, Shawano Co.	....	Gustavus Lawrence et al.
1869	290	Embarrass river.....	Shawano.....	E. R. Murdock, Sec. 19, T. 26 N., R. 15 E.
1869	361	Willow river, near Willow River Falls	St. Croix	Christian Buckhardt.
1869	400	Black Creek	Outagamie ..	Andrew Thompson et al., Sec. 31, T. 24 N., R. 18 E.
1869	411	Oconto river.....	Shawano.....	L. S. Lindsey, Sec. 5, T. 27 N., R. 18 E.
c 1869	452	Nimakogan river....	Bayfield.....	Nimakogan & T. Dam Co., T. 43 N., R. 6 W.
		Totagatic river.....	Washburn ...	Nimakogan & T. Dam Co., Sec. 12, T. 42 N., R. 10 W.
1870	32	Big Rib river.....	Marathon....	Jno. Linder, Sec. 6, T. 28 N., R. 6 E.
1870	48	Peckatonica river...	La Fayette..	Saterlee Warden, Secs. 1, 2, T. 1 N., R. 4 E.
1870	270	Little Wolf river....	Waupaca	Nathan Parker et al., Sec. 24, T. 25 N., R. 11 E.
1870	421	Peckatonica river...	La Fayette..	Chas. Sherman, Sec. 10, T. 4 N., R. 2 E.
1870	463	Red river..... ..	Shawano .	B. H. Overton, Sec. 2, T. 27 N., R. 14 E.
1871	85	Milwaukee river.....	Ozaukee	Julius Sizer, Sec. 11, T. 11 N., R. 21 E.
1871	239	Willow river, near Willow River Falls	St. Croix . .	Christian Buckhardt.
1872	38	Wisconsin river.....	Wood	Reuben C. Lyon, Sec. 8, T. 22 N., R. 6 E.
1872	60	Turtle creek	Rock	Jesse Pramer, Sec. 27, T. 2 N., R. 14 E.
d 1870	164	Eau Claire river.....	Douglas.....	St. Croix Dam Co., T. 44 N., R. 10 W.
		St. Croix river bet. mouth of Eau Claire and Moose rivers.		
		Yellow river.....	Burnett	T. 40 N., R. 16 W.
		Yellow river.....	Burnett	T. 39 N., R. 14 W.
		Yellow river..... .	Washburn....	T. 38 N., R. 13 W.
		Yellow river..... ...	Washburn...	T. 39 N., R. 12 W.
		Clam river...	Burnett	T. 39 N., R. 16 W.
		Nimakogan river.....	Washburn ...	Sec. 35, T. 41 N., R. 10 W.
		Nimakogan river.	Sawyer	Sec. 6, T. 41 N., R. 8 W.
1872	110	Milwaukee river.....	O aukee.. ...	J. B. Schanbly, Sec 34, T. 12 N., R. 21 E.
1872	112	Mack Key br. of Bean Brook.	Washburn....	Emil Munch et al, Sec 12, T. 39 N., R. 11 W.
1872	117	Eau Claire river....	Bayfield.....	Orange Walker et al, Sec. 16, T. 44 N., R. 9 W.
1872	132	Big Rib river	Marathon....	John Linder, Sec. 5, T. 28 N., R. 6 E.
1873	134	Chimpanzee brook...	Washburn....	Frederick Dresser, Sec. 28, T. 41 N., R 10 W.
		Bean brook..... .	Washburn....	Sec. 6, T. 39 N., R. 10 W.
		Bean brook.....	Washburn...	Sec. 8, T. 39 N., R. 10 W.
1873	135	Osceola creek.... ...	Polk.....	Samuel B. Dresser et al., Sec. 27, T. 33 N., R. 19 W.
1873	159	Little Wolf river....	Waupaca.....	C. S. Ogden, Sec. 34, T. 24 N., R. 13 E.
1873	245	Wood river.....	Burnett	Alvin N. Bugbee et al., Sec. 33, T. 39 N., R. 18 W.
1873	252	Totogatic river.....	Bayfield.....	Aaron M. Chase, T. 43 N., R. 8 W.
		Totogatic river.....	Bayfield ...	T. 43 N., R. 8 W.

a Amended, Chap. 220, Laws of 1868, correction of an error in the name of the grantee.
b Amended, Chap. 100, Laws of 1872, by substituting for the name Geo. A. Gore, the name George A. Gove.
c Amended, Chap. 164, Laws of 1870, by changing the name to St. Croix Dam Co., increasing capital stock and authorizing to build dams as follows:
d Re-enacted by Chap. 124, Laws of 1877.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1873	275	Moose river.....	Douglas.....	Louis E. Torinus, Sec. 35, T. 45 N., R. 13 W.
1874	118	Wisconsin river.....	Lincoln	B. F. Cooper et al., Sec. 12, T 31 N., R. 6 E.
1874	153	Clam river.....	Burnett	W. A. Talboys et al., Sec. 5, T. 37 N., R. 14 W.
1874	176	Elk river..	Price.....	John H. Redfield, Secs. 15, 23, T. 40 N., R. 1 E.
1874	204	Little Sandy river, a series of dams.	Marathon	V. Brooks et al. No description.
1874	228	Fisher river, series of dams.	Chippewa....	Loren D. Brewster et al. No description.
1874	239	Wisconsin river, series of dams.	Portage.....	John M. Robinson, Secs. 6, 7, 8, T. 23 N., R. 8 E.
1874	264	Lightning creek.....	Barron.	John H. Knapp, Sec. 24, T. 34 N., R. 14 W.
1874	276	Wisconsin river.	Wood.....	John Edwards, Secs. 2, 3, T. 21 N., R. 5 E.
1874	289	Little Wolf river	Waupaca.....	W. D. Mihills et al., Sec. 34 T. 25 N., R. 11 E.
1874	304	Moon's creek.....	Barron.	John H. Knapp et al, Sec. 16, T. 33 N, R. 14 W.
1874	306	Wisconsin river at the town of Rome.	Ashland.....	Hiram Russell. No description in bill.
1875	45	Clam river at Clam Falls.	Polk	Dan. F. Smith. No description.
1875	70	Wood river at Grantsburg.	Burnett.....	Canute Anderson et al. No description.
1875	91	Milwaukee river.....	Milwaukee ..	Chas. Herman, Sec. 18, T. 8 N., R. 22 E.
1875	169	Little Wolf river.....	Waupaca	J. M. Rounds et al., Sec. 15, T. 23 N., R. 13 E.
1875	195	Clam river.....	Polk	J. H. McCourt, Sec. 36, T. 37 N., R. 16 W.
1875	254	Rice creek.	Gates	Franklin Holman, Sec. 21, T. 33 N., R. 8 W.
1875	288	Sand creek.....	Barron	Elam Greeley, Sec. 5, T. 38 N, R. 14 W.
1875	362	Black river	Clark	Roberts & Whelen, Sec. 27, T. 31 N., R. 1 E., Sec. 21, T. 31 N., R. 1 E.
			Chippewa . .	Sec. 15, T. 32 N, R. 1 E.
1875	327	Clam river..... ..	Polk	John Glover, Sec 8, T. 36 N., R. 15 W.
1876	34	Trempealeau river ..	Trempealeau.	Wm. H. Decker, Sec. 17, T. 20 N, R. 10 W.
1876	105	Popple river and Brett creek.	Clark	Dudley J. Spaulding, Sec 17, T 27 N., R. 1 E, Sec. 23, T. 28 N., R. 1 E., Sec. 36, T. 29 N., R. 2 W., Secs. 22, 3, T. 29 N., R. 1 W.
1876	195	Sheboygan river.....	Sheboygan...	Geo. H. Brichner, Sec. 32, T. 15 N., R. 23 E.
1876	230	Little Wolf river	Waupaca	L. W. Bliss, Sec. 10, T. 24 N., R 13 E.
1876	232	Barham stream.. ...	Burnett	John Arbucle, Sec. 30, T. 38 N., R 14 W.
1876	265	Black river	Taylor	Roberts & Whelen, Sec. 14, T. 32 N., R. 1 E., Sec 15, T. 32 N., R. 1 E., Sec. 14, T. 32 N., R 1 E, Sec. 34, T. 32 N., R. 1 E., Sec. 21, T. 31 N., R. 1 E., Sec. 27, T. 31 N., R. 1 E.
1876	285	Wisconsin river, City of Portage.	.....	Solomen Leach.
1876	287	Wood river	Burnett...	John P. Jacobsen, Sec. 26, T. 38 N., R. 18 W.
1877	23	Leach creek..... .	Sauk	Peter Wilkinson et al., Sec. 13, T. 12 N., R. 7 E.
1877	236	Wedges creek..... ...	Clark	James Hewitt, Sec. 10, T. 24 N., R. 3 W.
1877	247	Yellow river, floating dams.	.....	Albert E. Pound. No description.
1877	267	Cunningham creek, to improve navigation, build dams, etc.	.....	Chauncy Blakeslee. No description in bill.
1878	163	Stony creek, to improve navigation, build dams.	.....	Chas. L. Fellows No description in bill.
1878	239	Mondeau creek.....	Taylor.	Wm. Miller, Sec. 3, T. 33 N., R. 1 W.
1878	271	Little Red river.....	Marathon....	Albert Wendorff, Sec. 11, T. 29 N., R. 6 E.
1878	272	Flambeau river.....	Price	Henry Hewitt et al., Sec. 22-3, T. 40, R. 3 E.
1878	283	Quaderer creek.....	Barron	John Quaderer, Sec. 28, T. 34 N., R. 12 W.
1878	284	Yellow river	Barron	John Quarer, Sec. 28, T. 34 N., R. 12 W.
1878	291	Sucker branch	Polk	W. L. Sadler, Sec. 26, T. 33 N., R. 17 W.
1878	318	Court Oreille series of dams.	....	Frederick G. Stanley et al, no description.
1878	337	Eau Claire river.....	Eau Claire...	Wm. A. Rust, Sec. 5-8, T. 26 N., R. 6 W.
1879	13	Little Eau Pleine river.	Marathon....	B. F. McMillan, C. S. McMillan, Sec. 17, T. 26, R. 3 E. Log driving.
1879	21	Big Eau Pleine river	Marathon....	N. J. White, Sec. 34, T. 29, R. 2 E. Log driving.
1879	28	O'Neil creek	Clark.....	W. T. Price, on said creek for log driving.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1879	53	South Maple creek..	Chippewa....	Mark Douglas, on said creek for log driving.
1879	55	Deer Tail river.....	Chippewa.... (now Gates.)	Daniel Shaw, Elias Moses, on said creek for log driving.
1879	71	Wiergor river.....	Chippewa....	Nicholas Abrahamson, Secs. 9, 16 & 21, T. 37, R. 7 W. Log driving
1879	90	Yellow river	Wood	Carl B. Long, A. E. Long, Sec. 34, T. 23, R. 3 E.
1879	96	Bear creek..	Barron.... ..	William Wilson, Andrew Tainter, T. B. Wilson, H. L. Stout, J. H. Knapp, Sec. 18, T. 36, R. 11 W. Log driving.
1879	112	Willow river.....	Polk	James & William Johnston, Sec. 29, T. 32, R. 15 W. Log driving.
1879	127	Cauley creek.....	Clark	G. H. Ray, on said creek for log driving.
1879	136	Red Cedar river.....	Burnett	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson, J. H. Douglas, Sec. 25, T. 37, R. 10 W.
a 1879	137	Yellow river	Barron	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson, J. H. Douglas, Sec. 34, T. 36, R 13 W.
1879	143	Little Chief river....	Chippewa....	A. J. Hayward, W. E. McCord, NE. NE. Sec. 26. T. 40, R. 7 W. Log driving.
1879	144	Pine Creek river.....	Chippewa....	William McKeith, Sec. 14, T. 37, R. 3 W. Log driving.
b 1879	147	Willow river.....	St. Croix	James & William Johnston, either Sec. 16 or 17, T. 31, R. 16 W. Log driving.
1879	154	Ten Mile creek	Chippewa....	William Wilson, Andrew Tainter, T. B. Wilson, H. L. Stout, J. H. Knapp, Sec. 30 or 31, T. 33, R. 9 W.
1879	155	Yellow river	Barron	William Wilson, Andrew Tainter, T. B. Wilson, H. L. Stout, J. H. Knapp, Sec. 7, T. 35, R. 12 W.
c 1879	191	Yellow river	Taylor.....	William Baker, Sec. 24, T. 32, R. 2 W. Log driving.
1879	201	Little Wolf river....	Waupaca	G. E. More, E. G. More, SE. NE. Sec. 1, T. 22, R. 13 E. Log driving.
1879	213	Wolf river.....	Shawano.....	C. D. Wescott, Mathias Miller, H. M. Loomer, NE. Sec. 25, T. 27, R. 15 E. Log driving.
1879	229	Mondeau creek.....	Taylor.....	J. B. Garland, between Sec. 17, T. 32, R. 1 E., & Sec. 13, T. 33, R. 1 W. Log driving.
1879	232	Clam river.....	Polk.....	John Glover, Sec. 31, T. 37, R. 15 W. Log driving.
1880	7	Kickapoo river.....	Crawford	T. W. Gay, J. A. Robb, S. A. Robb, lots 1 and 2, Sec. 28, T. 10, R. 4 W. Log driving.
1880	25	Wood river.....	Burnett	G. A. Erickson, P. E. Peterson, SW. Sec. 16, T. 38, R. 18 W. Log driving.
1880	26	Vermillion river .. .	Barron	F. R. Stees, Sec. 22, T. 35, R. 13 W.
1880	32	Turtle creek.....	Barron	Andrew Tainter, J. H. Knapp, H. L. Stout, William Wilson, T. B. Wilson, J. H. Douglas, Sec. 11, T. 33, R. 14 W. Log driving.
1880	33	Turtle creek.....	Barron	J. H. Douglass, Andrew Tainter, T. B. Wilson, H. L. Stout, William Wilson, J. H. Knapp, Sec. 27, T. 34, R. 14 W. Log driving.
1880	40	Hemlock creek.....	Barron	H. L. Stout, J. H. Douglass, William Wilson, J. H. Knapp, Andrew Tainter, T. B. Wilson, Sec. 36, T. 36, R. 10 W. Log driving.
1880	41	Hemlock creek.....	Chippewa....	H. L. Stout, J. H. Douglass, William Wilson, J. H. Knapp, Andrew Tainter, T. B. Wilson, Sec. 29, T. 36, R. 9 W. Log driving.
1880	49	Embarrass river.....	Shawano.....	F. S. Breed. N. ½ SW. Sec. 10, T. 26, R. 12 E.
1880	63	Spirit river	Lincoln	James McCrossen, SE. SW. Sec. 9, T. 34, R. 4 E. Log driving.
1880	75	Hay river.....	Barron.....	William Wilson, Andrew Tainter, J. H. Knapp, H. L. Stout, T. B. Wilson, J. H. Douglass. Sec. 32, T. 34, R. 13 W.

a Chap. 253, Laws of 1881, amends.
b Chap. 208, Laws of 1880, amends.
c Chap. 95, Laws of 1882, amends.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1880	76	Red Cedar river	Dunn	William Wilson, Andrew Tainter, J. H. Knapp, H. L. Stout, T. B. Wilson, J. H. Douglass, Sec. 13, T. 28, R. 13 W. Log driving.
1880	77	Black river	Taylor	A. E. Sawyer, David Austin, Richard Dewhurst, Sec. 30, T. 31, R. 1 W. Log driving.
1880	84	Christmas creek	Chippewa	C. W. Hanson, N ½ NW. Sec. 14, T. 31, R. 5 W. Log driving.
1880	92	Hemlock creek	Chippewa	T. B. Wilson, Andrew Tainter, William Wilson, H. L. Stout, J. H. Knapp, J. H. Douglass, Sec. 30, T. 36, R. 9 W. Log driving.
1880	97	Big Rib river	Marathon	Gustavus Werlich, SW. SE. Sec. 13, and NW. NE. Sec. 24, T. 30, R. 4 E. Log driving.
1880	102	Spirit river	Lincoln	K. A. Ostergreen, NW. Sec. 10, T. 34, R. 4 E. Log driving.
1880	103	Kickapoo river	Crawford	Atley Peterson, Peter Hooverson, NW. NE. Sec. 31, T. 11, R. 3 W. Log driving.
1880	144	Elk river	Price	A. B. Lunt, Peter Musser, NW. NW. Sec. 31, T. 38, R. 2 E. Log driving.
1880	151	Prairie river	Lincoln	T. B. Scott, Sec. 13, T. 32, R. 7 E. Log driving.
1880	168	Wisconsin river	Lincoln	P. B. Champagne, NE. Sec. 30, T. 33, R. 6 E.
1880	177	Otter creek	Clark & Chippewa.	DeLoss R. Moon, on Otter creek for log driving.
1880	178	Muskrat river	Eau Claire	DeLoss R. Moon, on Muskrat for log driving.
1880	182	Wolf river	Clark, Chippewa & Eau Claire.	DeLoss R. Moon, on Wolf river for log driving.
a 1880	184	Butternut creek	Price	D. P. Simmons, Sec. 18, T. 40, R. 1 W., for log driving.
1880	201	Spirit river	Price	G. W. Cate, N. N. McCloud, lot 4, Sec. 32, T. 34, R. 3. E. Log driving.
1880	205	Pine creek	Price	A. B. McDonnell, Sec. 18, T. 40, R. 2 W. Log driving.
1880	214	Poplar river	Oconto	Halver Annunson, John Annunson, Sec. 13, T. 38, R. 15 E. Log driving.
1880	241	Little Elk river	Price	Matthew Wadleigh, R. M. Mooer, A. D. Lunt, on Little Elk for log driving.
1880	255	Prairie river	Lincoln	Able Neff, W. ½ Sec. 14, T. 33, R. 8 E. Log driving.
1880	294	Deer Tail river	Chippewa	J. W. Heather, James McGee, Secs. 8, 9, and 16, T. 35, R. 4 W., and Sec. 24, T. 35, R. 5 W. Log driving.
1880	296	Hay creek	Chippewa	John Redmond, Secs. 16 and 17, T. 31, R. 5 W. Log driving.
1880	303	Black river, E. fork.	Wood, Clark & Jackson.	T. J. LaFlesh, Sec. 14, T. 23, R. 1 E., Secs. 5 and 30, T. 23, R. 2 E., Sec. 4, T. 22, R. 2 E. Log driving.
1881	41	Wood river	Burnett	J. P. Jacobson, Sec. 23, T. 38, R. 18 W. Log driving.
1881	57	Embarrass river	Shawano	F. D. Newbold, R. R. Livingstone, T. 26, R. 11 and 12 E. Log driving.
1881	58	Kewaunee river	Kewaunee	Wyota Strausky, SW. Sec. 14, T. 23, R. 24 E.
1881	67	Kickapoo river	Vernon	A. C. Cushman, NE. SE. Sec. 24, T. 12, R. 3 W. Log driving.
1881	77	Hay creek	Burnett	J. G. Nelson, Wm. Long, Sec. 12, T. 40, R. 11 W.
1881	88	Chippewa river	Eau Claire	Deloss R. Moon, Sec. 25, T. 27, R. 10 W., and Sec. 34, same town and range.
1881	160	Pine river	Lincoln	John Ross, J. E. Leahy, M. P. Bube, Sec. 22, T. 31, R. 7 E. Log driving.
1881	160	Pine river	Lincoln	John Ross, J. E. Leahy, M. P. Bube, Sec. 9, T. 31, R. 8 E. Log driving.

a Chap. 181, Laws of 1882, amends.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
a 1881	161	Wedges creek.....	Clark	James Hewett, NE. SE. Sec. 22, and NW. SW. Sec. 23. T. 25, R. 3 W. Log driving.
1881	164	Saylor creek.....	Price.....	E. E. LeClaire, T. 39, R. 1 E. Log driving.
1881	177	Fisher creek.....	Chippewa....	Eugene Shaw, D. P. Simmons, Sec. 34, T. 32, R. 6 W. Log driving.
1881	221	Silver creek.....	Taylor and Price.	John Duncan, any point on said creek. Log driving.
b 1881	255	Chippewa river.....	Chippewa. ..	Stanton Barnard, Sec. 4, T. 28, R. 8 W., and Sec. 26, T. 29, R. 8 W. Log driving.
1881	266	Yellow river	Chippewa....	Robert Jackson, Sec. 1, T. 29, R. 6 W.
1881	267	Plover river	Marathon....	E. G. Cory, SW. Sec. 19, T. 28, R. 10 E. Log driving.
1881	311	Aminicon river.....	Douglas.....	R. H. Henry, S. B. Barker, G. W. Henry, T. 46, R. 13 W. Log driving.
1881	326	Siscowit river.... ...	Bayfield.....	R. D. Pike, Isaac H. Wing, N. J. Willey, T. 51, R. 6 W. Log driving.
1881	327	Iron river....	Bayfield.....	R. D. Pike, J. H Knight, Isaac H. Wing, Jas. Barden, T. 50, R. 9 W. Log driving.
1881	331	Windfall creek.....	Chippewa....	John Morning, W. A. Rust, Sec. 16, T. 38, R. 8 W. Log driving.
1882	38	Embarrass river.....	Shawano.....	William Smith, SE. Sec. 9, T. 26, R. 14 E.
1882	78	Red Cedar river,. ...	Burnett..	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson, J. H. Douglass, Sec. 25, T. 37, R. 10 W., for log driving purposes.
1882	103	Red Cedar river.....	Barron.	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson, J. H. Douglass, SE. NE. Sec. 21. and Lot 3, Sec. 22, T. 36, R. 10 W., for log driving purposes.
1882	106	Wisconsin river.....	Portage.....	S. A. Sherman, Sec. 17, T. 23, R. 8 E., for log driving purposes.
1882	107	Big Plover river.....	Portage	C. A. Sherman, Sec. 26, T. 24, R. 8 E., for log driving purposes.
1882	137	Blake brook.....	Waupaca.....	Raymond Ayres, C. Rich, NE. Sec. 35, T. 24, R. 12 E., for log driving.
1882	145	Big Plover river.....	Portage.....	S. A. Sherman, Sec. 9, T. 23, R. 8 E. Log driving.
1882	182	Totogaticanse river..	Bayfield.....	J. E. Glover, Isaac H. Wing, W. H. Phipps, Sec. 8, T. 43, R. 9 W.
1882	183	Totogaticanse river..	Douglas.....	J. E. Glover, Isaac H. Wing, W. H. Phipps, Sec. 1, T. 43, R. 10 W.
1882	184	Totogaticanse river..	Bayfield.....	J. E. Glover, Isaac H. Wing, W. H. Phipps, Sec. 6, T. 43, R. 9 W.
1882	186	Big Eau Pleine river.	Marathon. ...	Christian Weber, NW. SE. Sec. 13, T. 27, R. 3 E.
1882	224	St. Croix river.....	Polk..	J. F. Mason, G. B. Burrows, W. J. Vincent, Wm. Amery, J. S. Baker At or near St. Croix Falls, for log driving.
1882	228	Jump river.....	Price.....	D. P. Simmons, NW. SW. Sec. 32, T. 34, R. 1 W., for log driving.
c 1882	247	Wisconsin river.....	Lincoln (now Oneida).	E. D. Brown, T. W. Anderson, A. W. Brown and W. E. Brown, Sec. 6, T. 36, R. 9 E.
1882	269	Babbs creek....	Sauk.....	A. P. Ellinwood, Sec. 9, T. 12, R. 4 E.
1882	270	Rock creek...	Clark	Phillip Rossman, Sec. 28, T. 27, R. 1 W., for log driving.
1882	292	Spring brook.....	Langlade	J. H. Weed, S. Bryant, Alfred Weed, E. ½ NE Sec. 31, T. 31, R. 11 E., for log driving
1882	297	Little Wolf river....	Waupaca	C. M. Wells, J. W. Ostrander, B. Ostrander, SW. SW. Sec. 8, T. 22, R. 14 E.
1882	316	Embarrass river.....	Shawano.....	Henry Stearns, SW. Sec. 9, T. 27, R. 12 E., for log driving.
1883	9	East Fork Black river.	Wood, Clark and Jackson	Thomas J. La Flesh, Sec. 25, T. 24 N., R. 2 E.

a Chap. 89, Laws of 1882, amends.
b Chap. 96, Laws of 1883, amends.
c Chap. 253, Laws of 1887, amends.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
a 1883	209	Black river.	Clark.....	James Hewitt, near outlet of O'Neill's creek.
b 1883	96	Chippewa river.....	.....	Stanton Bernard, amending 255, 1881.
1883	170	Copper creek	Lincoln.....	J. F. Ellis and J. R. Wilmot, NW. NE. Sec. 1, T. 31 N., R. 5.
1883	113	Duncan creek..	Chippewa....	Hector C. McRae, Jacob Luengle and John Miller, NW. NE. Sec. 6, T. 28 N., R. 8 W.
1883	75	Dunnum creek.....	Burnett.....	Erick Lundholm, Lot 3, Sec. 28, T. 38, R. 17 W.
1883	347	Fisher river.....	Chippewa....	Wm. Ervin, on said river for log driving.
1883	198	Hay creek..	Price.....	James Morrison, Edward Rutledge, SW. SW. Sec. 24, T. 36, R. 1 E.
c 1883	140	Kewaunee river.,....	Kewaunee ...	An act to amend Sec. 2, Ch. 58, Laws 1851.
d 1883	289	Little Black river...	Taylor	E. R. Urquhart, Peter Doyle, Joseph Brucher, W. Van Noslitz, SW. SW. Sec. 1, T. 30 N., R. 1 E.
1883	93	Little Eau Pleine river.	Marathon....	Joseph Meyer, Sec. 34, T. 27 N., R. 2 E.
1883	88	Little Yellow river	Wood	J. D. Witter, J. E. Ingraham, John Daly, H. A Samson, Secs. 19, 29, 30, 32, T. 21 N., R. 3 E.
1883	224	White river	Bayfield.....	John A. Humbird, at point where C. & St. Paul, M. & O. Ry. crosses.
1883	222	Long Lake river....	Burnett	John H. Knapp, Henry L. Stout, Andrew Tainter, Wm. Wilson, Thos. B. Wilson, John H. Douglas, SW. of SW. Sec. 24, T 37, R. 11 W.
1883	335	Marengo river.....	Bayfield	Robert Ritchie, S. ½ of SE. Sec. 27, T. 45 N., R. 5 W.
1883	11	Namakogan river....	Ashland.....	Anthony J. Hayward, Sec. 27, T. 41, R. 9 W.
1883	230	O'Neil river.....	Chippewa....	Marshall Miller, L C. Stanley, Sec. 29, T. 31, R. 8 W.
1883	130	Pine creek.....	Taylor	Thomas Kerns, Sec. 15, T. 30 N., R. 1 W. Log driving.
1883	132	Poplar river.....	Oconto	Halvor Annunson and John Annunson, Secs. 13, 14, T. 38 N., R. 15 E., Sec. 20, T. 38 N., R. 16 E.
1883	3	Red Cedar river	Dunn	John H. Knapp, Henry L. Stout, Andrew Tainter, Wm. Wilson, Thos. B. Wilson and John H. Douglas, Lots 2 and 6, Sec. 6, T. 28, R. 12 W.
1883	317	Robinson creek	Jackson.....	Hugh B Mills, T. 20, R. 2 W.
1883	355	St. German creek....	Lincoln (now Vilas).	John Arpin and P. B. Chapagne, Sec. 30, T. 40 N., R. 8 E.
1883	65	Scarbro creek.....	Kewaunee....	George Grimmer, Alex Trudell, William Bruemmer, SW. of SE. Sec. 25, T. 24. R. 23 E.
1883	259	Spring brook.....	Langlade	Louis Navotney and Joseph Navotney, west ½ NE. and east ½ NW. Sec. 29, T. 31 N., R. 11 E.
1883	21	Straight river.....	Polk.....	Nelson Lawson, J. H. McCourt, Lot 1, Sec. 20, T. 36, R. 16 W.
e 1883	33	Straight river.....	Polk.....	Isaac Staples, N. ½ SW. Sec. 18, T. 36, R. 16 W.; S. ½ NE Sec. 20, T. 36, R. 16 W.
1883	344	Totogaticanse river..	Douglas.....	S. L. Cowan, Isaac H. Wing and Wm. Phipps, SW. Sec. 30, T. 43, R. 10 W.
1883	213	Yellow river.....	Barron.....	Charles S. Taylor, John Post, SE. of Sec. 27, T. 34 N., R. 12 W.
1883	326	Yellow river.....	Taylor.....	J. F. Ellis, E. W. Allen, Sec. 27, T. 31 N., R. 4 W.
1885	43	Namakagon river....	Sawyer.....	A. J. Hayward, above village of Hayward, for log driving purposes.
1885	70	Ahnapee river.....	Door.	A. Fetzer, K. Youngs. E. ½ SW. Sec. 29, T. 26, R. 25 E.

a Chap. 88, Laws of 1885, amends.
b Amendment.
c Amendment.
d Chap. 377, Laws of 1887, amends.
e Chap. 108, Laws of 1887, repeals.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
a 1885	75	Namakagon river....	Washburn..	Jacob Bean, J. S. O'brien, Sec. 35, T. 41, R. 10 W., and other points on said river, for log driving purposes.
1885	100	Hemlock creek.....	Chippewa....	John H. Knapp, Henry L. Stout, Andrew Tainter, William Wilson, Thomas B. Wilson and John H. Douglass, W. ½ NW. Sec. 26, T. 36, R. 9 W.
1885	104	Elm creek.....	Sawyer.....	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson and John H. Douglass, Lot 4, Sec. 10, T. 37, R. 9 W.
1885	158	Wisconsin river.....	Wood.....	M. L. Beusley and Welcome Hyde, Sec. 8, T. 22, R. 6 E.
1885	180	Sand creek.....	Barron.....	J. T. Heath and L. B. Roice, N. ½ Sec. 17, T. 36, R. 14 W.
1885	231	Miller creek.....	Barron.....	J. H. Knapp, H. L. Stout, Andrew Tainter William Wilson, T. B. Wilson and J. H. Douglass, SW. Sec. 26, T. 36, R. 13 W.
1885	235	Embarrass river.....	Shawano.....	E. J. Homme, N. ½ NW. Sec. 10, T. 27, R. 11 E.
1885	236	Little Bear creek....	Barron.....	J. H. Knapp, H. L. Stout, Andrew Tainter, William Wilson, T. B. Wilson and John H. Douglass, SW. NW. Sec. 23, T. 36, R. 12 W.
1885	254	Apple river.....	Polk..... ..	John C. Schneider, S. ½ NE. Sec. 12, T. 32, R. 17 W.
1885	255	Embarrass river.....	Shawano.....	Carl J. Berg and Nils A. Madson, NW. NW. Sec. 23, T. 27, R. 12 E.
1885	278	Wisconsin river.....	Wood.....	R. C. Lyons, Sec. 18, T. 22, R. 6.
1885	280	Red river..... ...	Shawano.....	George J. Hahn, NW. Sec. 3, T. 27, R. 14 E.
1885	281	Embarrass river.....	Shawano.....	John Sieber and William Dumke, E. ½ SW. Sec. 15, T. 27, R. 13 E.
1885	282	Embarrass river.....	Shawano.....	Theodore Buettner, NW. Sec. 23, T. 26 R. 13 E.
1885	283	Apple river.....	Polk..	John C. Schneider, SE. NE. Sec. 11, T. 32, R. 17 W.
1885	363	Sheboygan river.....	Sheboygan ..	Henry Huson, SE. Sec. 13, T. 16, R. 20 E.
1885	367	Popple Creek.....	Price	G. W Mason, David Dubach, Allen Burdette and G. W. Prescott, Sec. 28, T. 38, R. 2 E.
1885	371	Lewis creek	Jackson.....	Oliver Darwin, T. 21, Ranges 2, 3 and 4 W. One or more dams for log driving purposes.
1885	372	Deer brook	Langlade	M. G. Harlow & W. H. Luce, SW. NE. Sec. 30 T. 32, R. 11 E., for log driving purposes
1885	402	Wood river	Burnett	Canute Anderson, SE. SE. Sec. 28, T. 38, R 18 W.
1885	412	Plover river.....	Marathon....	H. M. Wadleigh, NE. SW. Sec. 19, T. 28, R. 10 E. For log driving purposes.
1885	434	Milwaukee river. ...	Milwaukee...	City of Milwaukee in City of Milwaukee.
1887	12	Wisconsin river.....	Lincoln.....	William H. Bradley, Sec. 10, T. 34, R. 6 E.
1887	23	Wisconsin river.....	Wood.....	Centralia Pulp & Water Power Co., Sec. 24, T. 22, R. 5 E.
1887	41	Tomahawk river....	Lincoln	C. D. Hammond, H. C. Baker, W. W. Rich, P. B. Champagne, W. H. Eustis, Secs. 4 or 9, T. 35, R. 6 E.
1887	68	Montreal river.....	Iron	Benj. Heinemann, at any point or points on said river to be selected by the grantee.
1887	70	Big Eau Pleine river	Marathon....	W. H. Richards, NW. SE. Sec. 4, T. 27, R. 3 E.
1887	85	Tea river.....	Sawyer.....	John England, either on Sec. 3, T. 41, R. 6 W., or Sec. 34, T. 42, R. 6 W.
1887	113	Apple river.....	Polk.....	William Wilson, Amos E. Jefferson and Chas. T. Fox, either Sec. 28 or Sec. 33, T. 33, R. 16 W.
1887	117	Tamarack creek.....	Oneida.....	M. P. Beebe and H. Cline, building dams on said creek for log driving purposes.

a Chap. 154, Laws of 1887, amends.

***Grants of dam privileges by the legislature of Wisconsin*—Continued.**

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1887	135	Apple river.....	St. Croix	S. W. Campbell, NW. NE. Sec. 11, T. 31 R. 18 W.
1887	176	Yellow river.....	Barron.....	J. W. Taylor, NW. Sec. 27, T. 34, R. 12 W.
1887	177	Trade river	Burnett.....	Frederick Petterson, W. ½ NE. Sec. 22, T. 37, R. 18 W.
1887	178	Blake's lake.....	Polk	Samuel Harriman, G. P. Anderson and Abram Johnson, Sec. 26, T. 35, R. 16 W.
1887	218	Apple river.....	Polk	John C. Schneider, William Wilson, NW. NE. Sec. 6, T. 34, R. 15 W.
1887	223	Tatogatic river	Washburn...	G. A. Torinus, Sec. 12, T. 42, R. 12 W.
1887	251	Robinson creek	Jackson	Hugh B. Mills, maintain dam or dams in T. 20, Ranges 1, 2, 3 and 4 W., for log driving purposes.
1887	254	Clam river.....	Burnett.....	W. J. Vincent, James Thompson and J. B. Jones, T. 39, R. 16 W.
1887	262	Duncan creek.....	Chippewa....	Jacob Leinenkugel, NE. NE. Sec. 6, T. 28, R. 8 W., in city of Chippewa Falls.
1887	273	Devil's creek	Sawyer	Malcom Doble, NE. NW. Sec. 3, T. 38, R. 8 W., also other dams on said creek for log driving purposes.
1887	299	North Fork, Eau Claire river.	Clark	Jacob Bye, Sec. 28, T. 29, R. 4 W.
1887	329	Bear creek.	Oneida (now Vilas).	Chas. H. Henry, Secs. 1 and 2, T. 40, R. 4 E.
1887	339	Big Rib river.....	Marathon .	D. H. Johnson, Fred Reitbrook and L. W. Halsey, between SW. ¼ Sec. 8 and Sec. 6, T. 29, R. 5 E.
1887	346	Tomahawk river	Lincoln	D. J Arpin, E P. Arpin and W. G. Collins, SW. ¼ Sec. 28, T. 35, R. 6 E.
1887	386	Squaw creek.....	Price	James Quail and John Quail. From its mouth to Sec. 16, T. 38, R. 1 E., for log driving purposes.
1887	407	Montreal river.....	Ashland (now Iron).	Daniel C Rifield, at point or points in Sec. 34, T. 46, R. 2 E., for log driving purposes.
1887	434	Squirrel river.....	Oneida	J. D. W. Heath, T. 39, R. 5 E., for log driving purposes.
1887	438	Black river	Jackson.. ..	D. J. Spaulding, E. L. Brockway, Sec. 22, T. 21, R. 4 W.
1887	444	Peshtigo river	Forest.....	George R. Hall, Sec. 28 or Sec. 33, T. 37, R. 15 E.
1887	448	Trade river.....	Burnett	C. J. Akerlind, SE. SE Sec 16, T. 37, R. 18 W.
1887	449	Flambeau river (N. Fork).	Oneida (now Vilas).	C. H. Henry, T. 42, R. 5 E., for log driving purposes.
1887	512	Eagle river..	Oneida (now Vilas).	Leander Choate, W. H. Bradley, George Gerry and Walter Scott, Sec. 31, T. 40, R. 10 E.
1887	532	Eagle river	Forest (now Oneida).	J. P. Underwood, Geo. Gerry, Henry Sherry, S. ½ Sec. 5, T. 39, R. 11 E.
1889	366	Beaver brook.....	Polk.....	Joel Richardson, SW. of the NE. and NE. of SE. Sec. 5, T. 33 N., R. 15 W.
a 1889	445	Chief river..... ...	Sawyer.....	James Wright, Sec 16, T. 41 N., R. 7 W., & other localities along said stream.
1889	270	Eagle river..... .	Oneida	Leander Choate, W. H. Bradley, George Gerry, Walter Scott, Sec. 31, T. 40 N., R. 10 E.
1889	449	Embarrass river.....	Shawano.....	Herman Schwanke, Herman Wilkes and H. A. Wichman, Sec. 13, and Lot 26, R. 11 E.
1889	372	Fox river.....	Outagamie ..	Henry J. Rogers & August L. Smith, Lots 6 & 7, Sec. 24, S. of river to lots 2 & 3, Sec. 22 N. of river, T. 21 N. R. 18 E.
1889	77	Four mile creek	Marathon....	Freeman & Fellows Lumber Co. on said creek for log driving.
1889	485	Little Bear creek....	Oneida	John T. Cosgriff, on SW. of SE. Sec. 7, T. 41, R. 5. E.
1889	398	Little Somo river....	Lincoln	John Woodlock, Sec. 27, T. 35 N., R. 5. E.
1889	446	Moose river.....	Douglas.....	William Sauntry, T. 45, R. 13, Sec. 6, T. 44, R. 11 W. and T. 43 N., R. 13 W.

a Chap. 87, Laws of 1897, repeals.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1889	23	Pigeon river.....	Waupaca	John Nohr, Sr., Albert Nohr, & Wm. Nohr, SE. of SE. Sec. 15, T. 25 N., R. 13 E.
1889	45	Red river.....	Shawano.....	August G. Schmidt, NW. of NE. Sec. 3, T. 27, R. 14 E.
1889	44	Red river	Shawano.....	Charles Krueger & August Krueger, SE. of SW. and SW. of SE. Sec 8, T. 27, R. 15 E.
a 1889	215	St. Croix river.	Polk....	Amos E. Jefferson, James Thompson, SW. Chinn, Edward D. Lewis and Edward A. O'Brien, Sec. 22, T. 30 N., R. 20 E. Sec. 11, T. 33 N., R. 19 W. (Two dams.)
1889	405	Skinner creek...	Price	George W. Mason and Allan Burdette, Secs. 9, 15 and 19, T. 36, R 2 W.
1889	83	Squaw creek.....	Oneida	LeRoy Herrick, A. M. Sherman, NE. of the SE. Sec. 28, T. 40 N., R. 4 E.
1889	252	Tomahawk river.....	Oneida	David N. Benjamin, Wm. S. Stanley, Henry C. Payne, Secs. 10 & 15, T. 39 N., R. 6 E.
1889	481	Tomahawk river....	Oneida	John Arpin & Daniel J. Arpin, Sec. 21, T. 36 N., R. 6 E.
1889	394	White river.....	Bayfield.....	John S. Owen, Sec. 13, T. 45 N., R. 7 W.
1889	32	Wisconsin river.....	Wood	John Edwars & Walter A. Scott, Sec. 36, T. 22 N., R. 5 E.
b 1889	53	Wisconsin river.....	Wood.....	Thomas E. Nash, T. 21 N., R. 5 E.
1889	283	Wisconsin river.. ..	Portage.....	George A. Whiting, Wm. C. Whiting and R. C Russell, Sec. 8, T. 23 N., R. 8 E.
1889	407	Wisconsin river.....	Portage.....	Theodore A. Taylor and G. S. Biron, Secs. 6, 7, T. 23, R. 8 E.
1889	236	Wisconsin river.....	Wood.....	George S. Biron and Laura Biron, Sec. 34, T. 23 N., R. 6 E.
1889	316	Wisconsin river.....	Wood.....	Frank Garrison, John Farrish, E. B. Rossier, J. D. Witter, G. F. Steele, Sec. 24, T. 22 N., R. 5 E.
1889	235	Wolf river.....	Shawano.....	C. M. Upham, Mathias Miller, F. D. Naber, Secs. 25, 36, T. 27, R. 15 E.
c 1889	49	Yellow river	Burnett and Washburn.	Wm. Chalmers, Sec. 27, T. 39 N., R. 12 W.; Sec. 7, T. 40 N., R. 16 W.; Sec. 20, T. 39 N., R. 14 W.; Sec. 10, T. 38 N., R. 13 W.
1891	104	Tamarack river.....	Burnett..... ..	Wm. Sauntry, Sec. 6, T. 42, R. 15 W.
1891	110	Spruce river.... ...	Douglas .. .	Wm. Sauntry, NW. SE. Sec. 32, T. 44, R. 15 W.
1891	110	Spruce river.....	Douglas.....	Wm. Sauntry, SW. NW. Sec. 27, T. 44, R. 15 W.
1891	110	Spruce river.....	Douglas.....	Wm. Sauntry, NW. SE. Sec. 22, T. 44, R. 15 W.
1891	110	Spruce river	Douglas.....	Wm. Sauntry, SW. SW. Sec. 14, T. 44, R. 15 W.
1891	111	St. Croix river.....	Douglas.....	Wm. Sauntry, three dams at different points on west line of section 6, T. 44, R. 11 W.
1891	140	Flambeau creek.....	Price....	O. D. Van Dusen, Josiah Arnold, Fred Arnold, Lot 8, Sec. 6, T. 39, R. 1 E.
1891	142	Yellow river	Wood	Henry C. Paine, at or near the town of Babcock, T. 21, R. 3 E.
1891	148	Trade river.....	Burnett.....	Carl E. Peterson, Sec. 36, T. 37, R. 19 W.
d 1891	149	Spring Brook.....	Washburn ...	Wm. Chalmers, S. ½ SW. Secs. 6, N. ½ NW. Sec. 7, T. 39, R. 11 W.
1891	150	Oconomowoc	Washington .	E. W. Erercks, NE. NE. Sec. 25, T. 9, R. 18 E.
1891	170	Oak creek.....	Milwaukee...	Jos. Lindenmann, NW. SE. NE. SW. Sec 2, T. 5, R. 22 E.
1891	175	Red river.....	Shawano.....	G. J. Huhn, J. H. Baum, John Marx, N. ½ SW. SE. Sec 2. T. 27, R. 14 E.
1891	177	Wisconsin river.....	Oneida.....	Dan Graham, E. C. Allen, L. J. Cook, Sec. 26, T. 40, R. 9 E.
1891	186	Little Wolf river....	Waupaca	Jas. Meiklejohn and W. H. Hatten, copartners as Meiklejohn & Hatten, NW. SW. Sec. 15, T. 23, R. 13 E.

a Chap. 478, Laws of 1891, amends.
b No section given, so it cannot be located.
c Chap. 27, Laws of 1895, repeals.
d Chap. 28, Laws of 1895, repeals.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1891	222	Iron river	Bayfield	Patrick Hymes, building dams on said river for log driving purposes.
1891	229	Pine river	Forest	Henry Collett, J. S. Chase and Levi Collett, on north branch of Pine river.
1891	238	Pine river	Forest	Burton Ramsey, Chas. H. Jones, south branch of Pine river for log driving purposes.
1891	242	Eau Claire river	Marathon	Geo. Clayton, Chas. E. Parks, Sec. 7, T. 29, R. 10 E.
1891	284	Wisconsin river	Columbia	Town of Newport, in town of Newport.
* 1891	313	Chippewa river	Eau Claire and Chippewa.	Wm. F. Bailey, Henry W. Early, John Hunner and Jos. Mandelert. In the cities of Eau Claire and Chippewa Falls.
1891	395	Little Wolf river	Waupaca	A. W. Whitcomb and G. H. Fox, Secs. 23 and 26, T. 25, R. 14 E.
1891	396	Montreal river	Ashland	Jas. McCrassen and J. T. Barber, at any point or points between Island Lake and Sec. 27, T. 46, R. 2 E., for log driving purposes.
1893	111	Black river	Clark	M. C. Ring, town of Pine Valley, Clark county.
1893	221	Clam river	Burnett	John Arbuckle, SE. of NE. Sec. 5, T. 37 N. of R. 14 W.
1893	264	Clam river	Burnett	John Arbuckle, NE. Sec. 30, T. 38 N., R. 14 W.
1893	203	Comet river	Shawano and Waupaca.	James Spaulding, Sec. 21, T. 26 N., R. 11 E. Sec. 34, T. 26 N., R. 11 E., county of Shawano, also Sec. 12, T. 25 N., R. 11 E. county of Waupaca.
1893	50	Devil creek	Lincoln	Carl Kleinschmidt, east ½ of NE. Sec. 20, T. 31 N., R. 6 E
1893	194	Elder creek	Taylor	Charles W. Hanson, Sec. 19, T. 31 N. R. 4 W.
1893	207	Embarrass river	Shawano	James Meiklejohn, S. ½ of the NE. & NW. of NE. Sec. 5, T 26 N, R. 13 E.
1893	122	Hay Meadow creek	Lincoln	Frederick Manecke, on the SE. of SW. Sec. 7, T. 32 N., R. 8 E.
1893	154	Little Rice river	Oneida	Thomas Christy, west ½ of NE. Sec. 23, T. 36 N., R. 5 E.
a 1893	190	Oconto river	Oconto	Merick Murphy, amending Sec. 129, 1851, and 32, P. and L., 1862.
1893	191	Oconto river	Oconto	N. H. Brokaw and E. A. Edmonds, lot No. 1, Sec. 2?, T. 28 N., R. 19, and T. 28 N., R 19 E., opposite side of river.
1893	129	Pecor brook	Oconto	Wm. Sommers, on the NE. of the NE. of Sec. 18, T. 29, R. 17 E.
1893	169	Pelican river	Oneida	Paul Brown and A. W. Shelton, Secs. 8, 9 and 16, T. 36 N., R. 9 E.
1893	266	Prairie river	Lincoln	John N. Connor and Sigmund Heineman, Sec 1, T. 31 N., R. 6 E.
b 1893	302	Sand river	Bayfield	Edward J. Thompson, Sec. 9, T. 50, R. 5 W., Sec. 1, T. 51, R. 5 W.
1893	99	White river	Ashland	George Donileson, Samuel C. Knowles and Henry Sherry, N. ½ NE. Sec. 6, T. 46 N., R. 4 W.
c 1893	118	Wisconsin river	Columbia & Sauk.	Kilbourn Manufacturing Co., Secs. 3, 4, 9, 10, T. 13 N., R. 6 E. (An act to amend Ch. 424 of the private and local laws of 1866.)
1893	213	Wisconsin river	....	Wisconsin River Improvement Co., Sec. 8, T. 22 N., R. 6 E.
1893	143	Wisconsin river	Lincoln	Edward D. Brown, Thomas W. Anderson, Anderson W. Brown, Webster E. Brown, Sec. 6, T. 36 N., R. 9 E, Oneida county.
1893	138	Wisconsin river	Marathon	Joseph Desert, Louis Desert, H. M. Thompson, T 27 N., R. 7 E.

*Old dam have been maintained here for many years. No improvements recently.
a Amendment.
b Two dams.
c Amendment.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1893	96	Wisconsin river	Marathon....	J. D. Ross, W. D. Silverthorn, T. 28 N., R. 7 E.
1893	209	Wisconsin river	Wood	George S. Biron and Laura Biron, Sec. 34, T. 23 N., R. 6 E.
a 1893	210	Wisconsin river	Wood	Bertrand G. Chandos and George E. Hoskinson, lots 4, 7 & 8 in Sec. 8, T. 22 N., R. 6 E
1895	210	Big Eau Pleine river.	Marathon	John E. McMullen, T. 29, R. 2 E.
1895	172	Black river.....	Clark	E. E. Finney, T. 2[illegible], R. 2 W.
1895	346	Chippewa river.	Ashland. ...	Geo. L. Rogers and R. A. Cook, Sec. 12, T. 42, R. 2 W.
1895	357	Fisher river.	Chippewa....	Warren Flint and Edward Porter, Sec. 34, T. 32, R. 6 W., and Sec. 4, T. 31, R. 6 W.
1895	99	Hemlock creek.....	Wood	D. J. Arpin, E. P. Arpin, Jos. L. Dugas, Secs. 17-19 or 20, T. 22, R 4 E.
1895	251	Little Wolf river...	Waupaca ...	N. G. Nelson, Sec. 21, T 23, R. 13 E.
1895	234	Peshtigo river.....	Forest	Frank E. Cook, Secs. 28 and 33, T. 37, R. 13 E.
1895	60	Turtle river.	Iron	Henry Sherry and A. L. Maxwell. Any part of Iron county.
b 1895	272	Wisconsin river	Oneida	Edward D. Brown, Theodore W. Anderson, Anderson W. Brown and Webster E. Brown, Sec. 6, T. 36, R. 9 E.
1895	77	Wisconsin river	Wood	Lewis N. Alexander, Sec. 36, T. 22, R. 5 E.
c 1895	82	Wisconsin river	Wood	Bertrand G. Chandos and Geo. E. Hoskinson, at Grand Rapids, Sec. 8, T. 22, R. 6 E. (Amending Chap. 210, Laws of 1893.)
1895	345	Wisconsin river	Wood	Lewis N. Alexander. Sec. 36, T. 22, R. 5 E.
1895	58	Wolf river	Shawano....	Chas. M. Upham and F. W. Humphrey, Sec. 1 or 13, T. 27, R. 15 E.
1895	98	Wood river.....	Burnett	Hickerson Roller Mill Co., NW. SW. Sec. 14, T. 38, R. 19 W.
d 1895	101	Yellow river.....	Burnett	Abe Johnson, Sec. 7, T. 40, R. 16 W.
d 1895	101	Yellow river	Burnett	Abe Johnson, Sec. 20, T. 39, R. 14 W.
1897	206	Beaver creek.	Juneau	J. F. Hamilton, Chas. T. Baker and Horace Miner, Sec. 33, T. 19, R 2 E.
1897	207	Cranberry creek.....	Burnett..	Sidney H. Waterman, Sec 15, T. 38, R. 15 W.
1897	143	Hay river.....	Barron..	W. B. Curtis, N. ½ Sec. 18, T. 35, R. 13 W.
1897	266	Middle river.	Douglas	Kirby Thomas, N. B. Arnold and A. B. Mills, Sec. 10, T. 47, R. 12 W.; Sec. 35, T. 49, R. 12 W.
1897	145	Oconto river.....	Oconto.....,....	Geo. W. Volk, Lots 1 and 3, Sec. 26, T. 28, R. 19 E.
1897	240	Oconto river.....	Oconto.....	Geo. Beyer and Chas. Hall, Sec. 31, T. 28, R. 20 E.
e 1897	211	Rat river.....	Forest.....	Wm. Fellows, SE. SE. Sec. 25, T. 36, R. 14 E.
1897	284	Gilbert creek.....	Dunn....	Maitland H Wilcox, SE. NW. Sec. 26, T. 28, R. 14 W.
1897	190	Wisconsin river.....	Vilas.....	Wm. J. Walsh, Fred. Morey, W. A. Bradford, Lots 7 and 8. Sec. 36 T 40, R. 9 E.
1899	134	Elk Creek.....	Dunn.....	James E. Rork, NW. of NE. Sec. 12, T. 27 N., R. 11 W.
1899	144	Apple river	St. Croix	Frank W. Epley, Henry Floy, George M. Brill, SE. of SE. Sec. 35, T. 31 N., R. 19 W.
1899	172	Apple river.....	St. Croix	Frank W. Epley, SW. of Sec. 26, T. 31 N., R 19W
1899	177	Little Wolf river....	Waupaca	W. H. Hatton & Arthur Lindsay, NW. SW. of Sec. 15, T. 23 N., R. 13 E.
1899	195	Waupaca river	Waupaca	R. N. Roberts & Samuel T. Osborn, Lots 124 and 125, of the village, now the city, of Waupaca.
1899	209	Chippewa river.. ..	Chippewa	Angus J. McGilvray, Sec. 30, or 29 and 30, T. 30 N., of R. 7 W.
1899	227	Oak creek	Dunn.	J. P. Ausman, NE. of SE. Sec. 12, T. 27 N., R. 11 W.

a Chap. 82, Laws of 1895, amends.
b Amending Chap. 247, Laws of 1882; Chap. 253, Laws of 1887; Chap. 143, Laws of 1893.
c Amendment.
d Chap. 141, Laws of 1897, repeals.
e Chap. 122, Laws of 1901, amends.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1899	261	Peshtigo river.....	Marinette....	Hieronymus Zech, Sec. 1, T. 32 N., R. 18 E. Sec. 33, T. 32 N., R. 19 E.
1899	320	Flambeau river	Price	Abbie Sherry & Frank T. Russell, Lots 4 & 5, Sec. 13, Lot 3 of Sec. 24, T. 40 N., R. 1 W. Lot 6 of Sec. 25, T. 40 N., R. 1, W. Lot 1, Sec. 25, same town and range.
1899	331	Manitowish river....	Vilas	H. W. Wright, Sec. 14, T. 41 N., R. 6 E.
1901	55	Prairie river	Lincoln....	Emil Thomas, Sec. 12, T. 32 N., R. 7 E.
a 1901	122	Rat river	Forest	William Fellows, amending 211, 1897.
1901	177	Namakagon river....	Washburn ...	Jacob Bean and James S. O'Brien. Below the range line between Rs. 9 and 10.
1901	185	Apple river.....	St. Croix ..	F. W. Apley, on the NE. ¼ of the SW. ¼ Sec. 31, T. 31 N., R. 18 W.
1901	198	Little Wolf river....	Waupaca	Casper Faust, in the SW. ¼ of the SE. ¼ of Sec. 8, T. 22 N., R. 14 E.
1901	260	Wood river.....	Burnett	Adolphus P. Nelson, SW. ¼ NW. ¼ Sec. 22, T. 38 N., R. 19 W
1901	261	Big Plover river . .	Portage.....	Horace E. Horton, SW. ¼ of NE. ¼ Sec. 9, T. 23 N., R. 8 E.
1901	262	Lilly river.	Langlade and Forest	W. H. Dick. From mouth of said river to north line of T. 34.
1901	264	Embarrass river.....	Shawano.....	W. H. Dick, NE. ¼ of NW. ¼ Sec. 36, T. 27, R. 12 E. Also on NW. ¼ SE. ¼, Sec. 7, T. 26, R. 14 E.
1901	292	Flambeau river.....	Chippewa....	Angus J. McGilvray, Sec. 35, T. 36 N., R. 5 W.
1901	294	Black river.....	Clark	L. B. Ring, Secs. 22, 26, T. 24 N., R. 2 W.
1901	365	Trapp river	Marathon....	Walter Alexander, Benjamin Heinemann and H. C. Steward, Secs. 12, 13, T. 30 N., R. 8 E.
1901	366	Pine river.....	Lincoln	Geo. E. Foster Lumber Co., Secs. 9, 10, T. 31 N., R. 8 E.
1901	455	Flambeau river.....	Chippewa....	Charles R. Smith, Henry S. Smith, L. J. Noble, north ½ of Sec. 30, T. 35 N., R. 5 W. Lots 7 and 1, Sec. 2, T. 34 N., R. 6 W.
1901	462	Wisconsin river.....	Sauk and Columbia.	William Gunther, A. D. Johnson, A. B. Whitman, Lot 4, Sec. 4, T. 13 N., R. 6 E. Lots 1 and 2, Railroad Add. to Kilbourn City.
1903	24	St. Croix river	Polk	St. Croix Falls Wisconsin Improvement Co., at or near St. Croix Falls.
1903	26	Pelican river.....	Oneida.....	Antigo Island Club, at outlet of Pelican lake, Sec. 11, T. 35, R. 10 E.
1903	59	Chippewa river	Eau Claire...	City of Eau Claire.
1903	62	Flambeau river.....	Rusk	O. E. Pederson and L. E. McGill, Lots 2, Sec. and 7, 18, T. 34, R. 6 W.
1903	145	Wisconsin river	Lincoln	Edward Bradley and Wallace G. Collins, Secs. 3 and 10, T. 53, R. 6 E.
1903	153	Wisconsin river	Marathon ...	G. D. Jones and Neal Brown, Secs. 13 and 14, T. 30, R. 7 E.
1903	154	Wisconsin river... .	Lincoln	Alexander Stewart and Walter Alexander, Secs. 19, 20, 29, 30, 31, T. 33, R. 6, and Sec. 6, T. 32, R. 6 E.
1903	155	Wisconsin river	Marathon ...	J. D. Ross, Charles J. Winton and E. W. Brooks, T. 28, R. 7 E.
1903	156	Wisconsin river ...	Marathon ...	C. J. Winton, Secs. 32 and 33, T. 26, R. 7 E.
1903	172	Chippewa river.....	Chippewa....	David R. Davis and William L. Davis, south half Sec. 30, T. 30, R. 7 W.
1903	172	Chippewa river.....	Chippewa....	David R. Davis and William L. Davis, Lot 1, Sec. 29, and Lot 4, Sec. 20, T. 30, R. 7 W.
1903	174	Apple river	Polk	A. P. Bixby and Andrew Bottolfson, Sec. 30, T. 32, R. 17 W.
1903	178	Chippewa river	Chippewa....	Cornell Land & Power Co., at Brunette Falls, Sec. 18, T. 31, R. 6 W.

a Amendment.

NOTE.—For the years 1879 1880, 1881, 1882, and part of 1885, 1887 and 1891, where the dams are authorized exclusively for log or driving purposes, it will be found so indicated.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1903	180	Long Lake river....	Chippewa....	Long Lake Improvement Co., at or near outlet of Long Lake, Lot 3, Sec. 18, T. 32, R. 8 W.
1903	181	Brule river	Douglas.....	Alwin A. Muck, Sec. 22, T. 47, R. 10 W.
1903	182	Black river	Jackson.....	La Crosse and Black River Railroad Co., Lots 2 and 8, Sec. 1, T. 21, R. 4 W.
1903	206	Black river	Jackson.....	La Crosse and Northern Railway Co., either Lot 5, Sec. 1, or Lot 7, Sec. 2, T. 18, R. 8 W.
1903	209	Pecor brook	Oconto	Robert Gregnon, NE of NW. and W. ½ of NW. of Sec. 18, T. 29, R. 17.
1903	210	Red Cedar river.....	Dunn	Daniel C. Baldwin and Hannah C. Baldwin, Sec. 8, T. 29, R. 11 W.
a 1903	220	Apple river	St. Croix ...	F. W. Eoley, SW. NE. Sec. 31, T 31, R. 18 W. (Amendment to Chap. 185, Laws of 1901.)
1903	223	Copper river.....	Lincoln	Heirs of Richard Schen, NE. SW. Sec. 4, T. 31, R. 5 E.
1903	231	Chippewa river.....	Chippewa....	John W. Thomas, Secs. 1 and 12, T. 29, R. 8 W.
1903	239	Wisconsin river	Oneida.....	E. S. Shepard and A. W. Shelton, Secs. 23 and 27, T. 36, R. 8 E.
1903	243	Black river	Clark	Charles C. Smiteman, at or near the city of Neillsville.
1903	244	Long Lake creek....	Iron	J. H. Palmer, T. 43 and 44, R. 3, E.
1903	288	Red river	Shawano.....	A. C. Weber, Secs. 21 or 22, T 27, R. 15 E.
1903	308	Menominee river ...	Marinette .	Powell Stack House, lot 2 or 3 or both, Sec. 22, T. 38, R. 21 E.
1903	310	White river.....	Waushara ...	Frank J. Kipp, Sec. 24, T. 18, R. 10 E., and Sec. 19, T. 18, R. 11 E.
1903	340	Chippewa river	Sawyer.	E. T. Harmon, Secs. 23 and 26, T. 38, R. 7 W.
1903	353	Black river....	Jackson.....	Erwin G. Boynton and Orlando Holway, Sec. 3, T. 22, R. 3 W.
1903	364	Tomahawk river...	Vilas	John Woodlock, SW. Sec. 18, T. 39, R. 6 E.
1903	365	Little Wolf river ...	Waupaca	H. M. Seaver, NE. Sec. 34, T. 24, R. 13 E.
1903	385	Embarrass river	Waupaca	E. F. Decker, SW. Sec. 5, T. 25, R. 15 E.
1903	400	Kickapoo river.....	Vernon	G. W. Henika and C. W. Fowell, village of Reedstown.
1905	11	Yellow river..... ..	Washburn ...	Village of Spooner, NW. ¼, SE. ¼, Sec. 31, T. 39, R. 12 W. Legal head 15.
1905	39	Plover river.....	Portage	Stevens Point Power Company, NW. ¼ SW. ¼ Sec. 12, T. 24 N., R. 8 E. Legal head 14.
1905	69	Elk creek	Dunn	Thomas B. Wilson, NE. ¼ NE. ¼ Sec. 24, T. 27, R. 17 W.
1905	350	Embarrass river.....	Shawano.....	W. H. Dick, (a) E. ½ SE. ¼ Sec. 32, T. 28 N., R. 13 E., (b) SE. ¼ NW. ¼, Sec. 15, T. 27 N., R. 13 E.
1905	397	Fox river	Outagamie...	J. S. Van Nortwick et al., Lower Rapids, Kaukauna. Legal head 27.
1905	398	Pelican river.	Oneida	W. E. Brown et al., S. ½ SE. ¼ Sec. 4, N. ½, NE. ¼ Sec. 9 or T. 36 N., R. 10 E. Legal head 6.[1]
1905	399	La Crosse river.	La Crosse ...	Steven Steenson, SW. ¼ Sec. 33, T. 17 N., R. 6 W. Legal head 12.[2]
1905	400	Flambeau river.....	Iron.....	Charles A. Gesell, W. ½ Sec. 4, T. 41 N., R. 2 E. (Concrete.) Legal head 35.[1]
1905	401	Red Cedar river.....	Barron	Sewall A. Peterson, P. M. Palmer, et al., E. ½ NW. ¼ Sec. 32, T. 35 N., R. 11 W. Legal head 15.[2]
1905	407	Wisconsin river	Lincoln	J. A. Barrett, D. E. Dawson, et al., Lot 5 in Sec. 19 across river to Lot 3, Sec. 20, T. 31 N., R. 7 E. Legal head 13.
1905	408	Big Somo river.....	Lincoln	Stolle-Baradt Lumber Company, Sec. 4, T. 35 N., R. 4 E. Legal head 9.
1905	409	Jump river.....	Rusk	John Casgriff, Sec. 26, T. 33 N., R. 5 W. Legal head 20.

a Amendment.
[1] From bed of stream.
[2] Measured from low water in river.

Grants of dam privileges by the legislature of Wisconsin—Continued.

Laws of	Chapter or number.	River.	County.	Name of grantee, land description, section, township and range.
1905	410	White river	Bayfield	J. B. Matthews et al., Sec. 1, T. 46 N., R. 5 W. Legal head 45.[2]
1905	411	Main creek	Rusk	G. E. Newman, Sec. 31, T. 34 N., R. 5 W. Legal head 15.
1905	415	Pine river	Florence	E. W. Hopkins, Sec. 28, T. 39 N., R. 18 E. (Above normal.) Legal head 32.
1905	457	Wolf river	Langlade	F. J. Robert, E. H. Van Ostrond, M. J. Wallrick, E. ½ SW, ¼ Sec. 10, T. 31 N., R. 14 E. Legal head 26.
1905	464	Wisconsin river	Lincoln	E. T. Harmon et al., L. N. Anson, John O'Day, Lots 2, 3, 6, 7, Sec. 30, T. 33 N., R. 6 E. Legal head 32.
1905	470	Black river	Clark	City of Greenwood, Sec. 34, T. 27 N., R. 2 W. Legal head 16.[2]
1905	483	Wisconsin river	Vilas	Town of Eagle River, Lots 7 & 8, Sec. 36, T. 40 N., R. 9 E. Legal head 20.
1905	487	Oconto river	Oconto	Wm. C. Zachow, Lots 1 & 8, Sec. 33. Legal head 30.[1]
1905	491	Black river	Jackson	City of Black River Falls and J. J. McGillivary, E. ½ SE. ¼ Sec. 15, T. 21 N., R. 4 W. To increase head from 11 to 15. Legal head 15.
1907	644	Wisconsin river	Marathon	Beans Eddy Power Co., Secs. 6, 7, 8, T. 26, R. 7 E. Legal head 15.
1907	189	Wisconsin river	Sauk, Columbia.	J. S. Tripp, Magnus Swenson, Sec. 25, T. 10, R. 6 E. Legal head 18.
1907	405	Peshtigo river	Marinette	Crivitz Pulp Co., Sec. 21, T. 32, R. 19 E. Legal head 46.
1907	383	Peshtigo river	Marinette	C. E. Rollins, Sec. 15, T. 32, R. 19 E. Legal head 18.
1907	385	Eau Claire river	Eau Claire	Isrel Shroudy, Sec. 10, T. 26, R. 5 W.
1907	361	Flambeau river	Iron	State Land & Power Co., W. ½ Sec. 4, T. 41, R. 2 E.
1907	123	Flambeau river	Rusk	O. E. Pederson, Lots 2, 7, Sec. 18, T. 34, R. 6 W. Legal head 20.
1907	380	Chippewa river	Rusk	C. R. Smith, NE. ¼ Sec. 23, T. 36, R. 7 W. Legal head 26.
1907	626	Chippewa river	Sawyer	John Arpin Lumber Co., Sec. 10, T. 37, R. 7 W. Legal head 18.
1907	35	Chippewa river	Eau Claire	City of Eau Claire. Legal head 32.
1907	675	Flambeau river	Chippewa	A. J. McGilvray, Sec. 35, T. 36 R. 5 W.
1907	286	Yellow river	Chippewa	Jacob Svetlik, NE. ¼ Sec. 31, T. 29, R. 6 W. Legal head 10.
1907	158	Big Plover river	Portage	A. Van Order, SE. ¼ Sec. 1, T. 24, R. 8 E. Legal head 4 ft. additional.
1907	590	Sioux river	Bayfield	City of Washburn, NE. ¼ Sec. 19, T. 49, R. 4 W. Legal head 60.
1907	549	Rock river	Jefferson	Watertown El. Co. Legal head 13.
1907	437	Little Wolf river	Waupaca	A. W. Whitcomb, N. line Sec. 26, T. 25, R. 12 E.
1907	416	Little Wolf river	Waupaca	F. M. Moffatt, SW. ¼ Sec. 22, T. 25, R. 12 E. Legal head 15.
1907	284	Jump river	Rusk	J. C. Young, Sec. 34, T. 33, R. 5 W. Legal head 20.
1907	404	Wolf river	Langlade	E. P. Sherry, S. ½ Sec. 25, T. 31, R. 14 E. Legal head 35.
1907	409	Menominee river	Florence	Max Sells, Sec. 2 or 12, T. 39, R. 19 E. Legal head 32.
1907	489	Trout creek	Vilas	R. C. Schutz, SW. ¼ Sec. 14, T. 41, R. 6 E.
1907	514	Silver creek	Taylor	C. F. Stout, Sec. 12, T. 33, R. 1 E. Legal head 25.
1907	384	Brule river	Florence	J. J. Pontbriand, Sec. 9 to 15, T. 40, R. 18 E.
1907	359	Pine river	Florence	E. W. Hopkins, Sec. 28, T. 39, R. 18 E.
1907	381	Bad river	Ashland	W. M. Ruggles, Sec. 30, T. 45, R. 2 W. Legal head 80.
1907	449	Oconto river	Oconto	S. C. Frost, SW. ¼ Sec. 10, T. 31, R. 16 E. Legal head 20.

[1] Measured from the river bed.
[2] Measured from low water in river.

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